Operating and Maintenance Handbook

MARCONI INSTRUMENTS LIMITED, ENGLAND

F.M./A.M. SIGNAL GENERATOR

TYPE TF 995A/2

MP MASTER

MA237

OPERATING AND MAINTENANCE

HANDBOOK

for

FM/AM SIGNAL GENERATOR

TYPE TF 995A/2

Amendments

The following amendment is included at the commencement of the Appendices Section of this handbook.

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SPARES ORDERING SCHEDULE(with circuit references) SOS/995A/2

BLOCK SCHEMATIC DIAGRAM ..... TLC 23556/2

COMPLETE CIRCUIT DIAGRAM ..... TLD 23080/2

DECIBEL CONVERSION TABLE ..... OM G-SUPP DB

SCHEDULE OF PARTS SUPPLIED

The complete equipment comprises the following items:-

1. One F.M./A.M. Signal Generator Type TF 995A/2 complete with valves, etc., as under:-

Valves:	One:	OA2 (150C4), Voltage Stabilizer Tube.
	One:	5Z4G (52KU), Full-Wave Rectifier.
	Six:	6AK5 (EF95), Pentodes.
	Two:	6AK6, Pentodes.
	Two:	6AL5 (D77), Double Diodes.
	One:	6AU6 (EF94), Pentode.
	One:	12AT7 (ECC81), Double Triode.
	One:	5651 (QS83/3), Voltage Reference Tube.
Lamp:	One:	6.3-volt, 0.3-amp, M.E.S., Pilot Lamp.
Oscillator Crystal:	One:	333.3 kc/s, Marconi Type 1655C.
Semiconductor:	One:	Type CS2-A Silicon Diode.

2. One Terminating Unit Type TM 4308; 75 ohms in, 52 and 75 ohms out.

3. One Coaxial Free Plug, Belling-Lee Type L734/P; for Terminating Unit outlets.

4. One Jack Plug, S.T.C. Type 4006; for Crystal Check socket.

5. One Operating and Maintenance Handbook No. OM 995A/2.

The following accessory is an optional item supplied only if specially ordered.

20-dB Attenuator Pad Type TM 4736; for use between Terminating Unit and output cable.

1 DESCRIPTION

1.1 GENERAL

The Marconi F.M./A.M. Signal Generator TF 995A/2 covers the frequency range 1.5 to 220 Mc/s in five bands. Its output can be unmodulated, frequency modulated, or amplitude modulated; if required, both frequency and amplitude modulation can be applied simultaneously. The modulation is obtained from either an internal 1,000-c/s oscillator or an external source; for f.m., the deviation is variable up to a maximum of from 25 kc/s to 600 kc/s depending on carrier frequency; for a.m., the depth is variable up to 50%.

The open-circuit output voltage is variable by means of resistive step attenuators from 1 μV to 100 mV at 52 ohms and 1 μV to 200 mV at 75 ohms. A plug-on 20-dB Attenuator Pad, available as an optional accessory, extends the range down to 0.1 μV at both impedances. The inclusion of a carrier on/off switch makes it possible for the generator output to be temporarily interrupted without affecting the output impedance.

1.2 DESIGN DETAILS

1.2.1 R.F. Circuits

The r.f. oscillator itself is variable only over the fundamental frequency range of 4.5 to 9.16 Mc/s; the output bands of 13.5 to 27 Mc/s, 27 to 54 Mc/s, 54 to 108 Mc/s, and 108 to 220 Mc/s are obtained from a chain of four ganged harmonic multipliers of x3, x2, x2, and x2 respectively. The setting of the frequency switch determines which of the multipliers acts as the output stage.

Output over the 1.5- to 13.5-Mc/s band is obtained by applying the 27- to 54-Mc/s output of the second multiplier to a single-valve circuit which combines the functions of mixer and 30-Mc/s oscillator. The variable-frequency output from the second multiplier is thus heterodyned with a fixed 30-Mc/s signal, and the output from the oscillator mixer stage contains a difference-frequency component which is utilized - after filtering and amplification - to provide outputs between 1.5 and 13.5 Mc/s. The main tuning dial has five scales, all direct reading in output frequency; four of these scales are for the bands extending upwards from 13.5 Mc/s; and the fifth scale is for the

1.2.1 (continued)

1.5- to 13.5-Mc/s band. This fifth scale is calibrated directly in terms of the difference between 30 Mc/s and the output frequency of the multiplier; since the scale extends from 1.5 to 13.5 Mc/s, it covers an arc which corresponds to the second multiplier being tuned from 31.5 to 43.5 Mc/s.

Whichever r.f. band is in use, the ultimate output is derived via two resistive 75-ohm ladder-network attenuators in cascade. The first attenuator has a range of 80 dB and is variable in 20-dB steps; the second has a range of 20 dB in 2-dB steps. The input to the cascade is adjustable by means of the SET R.F. control and is monitored by a meter having a SET R.F. mark and, respectively above and below this mark, plus and minus 1-dB marks to allow interpolation between the 2-dB steps of the second attenuator. The output from the second attenuator is applied to a coaxial cable, which is permanently attached to the Signal Generator; the direct open-circuit output obtainable from this cable is at a source impedance of 75 ohms and is variable between 2 μV and 200 mV. By using the plug-on Terminating Unit supplied, outputs within the range 1 μV to 100 mV are obtainable at source impedances of both 52 and 75 ohms; with the optional Attenuator Pad interposed between the output cable and the Terminating Unit, outputs down to 0.1 μV are obtainable.

The built-in crystal calibrator - the crystal unit of which has a fundamental frequency of 333.3 kc/s - is coupled to the variable-frequency r.f. oscillator and provides fourteen checking points on each of the four upper frequency bands covered by the Signal Generator. The h.t. supply to the calibrator is automatically switched on by the insertion of a telephone plug into the CRYSTAL CHECK jack on the front panel; the heterodyne beats at the checking points may then be heard in the head telephones or via the receiver under test. The cursor of the tuning dial is adjustable so that it may be set to correspond exactly to the nearest crystal checking point.

To facilitate tuning, a slow-motion worm-and-wheel drive is incorporated; this control is fitted with a dial marked linearly from 0 to 100 to assist the operator in sub-dividing the frequency scales of the main tuning dial. In addition, there is a directly-calibrated incremental frequency control with a total range of ±50 kc/s on the 13.5- to 27-Mc/s band, this range increasing by a factor of 2 for each successive band to give a cover of ±400 kc/s on the 108- to 220-Mc/s band. On the 1.5- to 13.5-Mc/s band, the control has a cover of ±100 kc/s.

1.2.1 (continued)

For the application of the incremental carrier shift and for frequency modulation, a reactor valve is included in the tuned circuit of the r.f. oscillator. Movement of the incremental-frequency control varies the d.c. bias applied to the grid of the valve, causing a change in its mutual conductance and thus a change in the oscillator frequency. Both the a.f. modulating signal and the d.c. shift voltage are applied to the grid of the valve via a tracking potentiometer ganged to the main tuning capacitor so that the deviation or carrier shift is kept constant as the Signal Generator is tuned over any one band.

A carrier on/off switch is included to enable the r.f. signal to be interrupted without the output circuits of the generator being affected in any way. This is done by switching the h.t. supply to the screen of one of the harmonic multipliers; the multiplier selected depends on the setting of the RANGE switch.

1.2.2 Modulation Systems

Either internal or external a.f. modulation (f.m. or a.m.) may be applied; the internal modulation is derived from a 1,000 c/s oscillator.

For frequency modulation, the a.f. signal passes through a cathode follower and is normally fed to the reactor, not only through the variable tracking potentiometer, but also via a switched potentiometer system ganged to the range switch. By this means, the ratio of a.f. input voltage to f.m. deviation is maintained constant at all frequencies on every band and is independent of the setting of either the range switch or tuning control. The normal deviation ranges on all carrier bands are 0 to 25 kc/s and 0 to 75 kc/s. But switching is provided so that the switched potentiometer system can be by-passed, thus enabling the deviation to be increased proportionally with increase in frequency multiplication and giving a maximum deviation on the highest-frequency band of 75 x 8 = 600 kc/s. On the 1.5- to 13.5-Mc/s band, the maximum deviation obtainable is 150 kc/s.

Amplitude modulation, to a depth continuously variable up to 50%, is applied to the highest-frequency harmonic multiplier which is operating for the particular r.f. output band in use; this method helps to reduce the spurious frequency modulation often encountered when modulating an r.f. oscillator directly.

1.2.2 (continued)

Simultaneous amplitude and frequency modulation, of use, for example, when investigating the performance of limiter stages in f.m. receivers, is obtained by setting up the instrument for internal a.m. and then applying f.m. from an external source.

1.2.3 Monitoring Arrangements

A moving-coil microammeter on the front panel, used in conjunction with a crystal rectifier, continuously monitors the r.f. input to the attenuators when a spring-loaded key-switch is in the normal position; the two alternative positions are for reading f.m. deviation and a.m. depth respectively, the former by the measurement of the a.f. modulating voltage injected into the reactor valve and the latter by similarly checking the a.f. voltage being applied via the h.t.-feed circuit to the screen of whichever multiplier is operating as modulator stage. The design of the modulation monitoring circuits is such that, with the Signal Generator set up for simultaneous a.m. and f.m., both percentage depth and deviation can be read independently.

1.2.4 Power Unit

A full-wave rectifier provides positive d.c. h.t. requirements; in the case of the reactor and r.f. oscillator valves, the h.t. is stabilized by means of a gas-filled regulator tube. A negative supply for the reactor-valve bias is drawn from a voltage-doubling circuit employing a double-diode valve and a gas-filled stabilizer. The primary of the transformer is tapped to allow for operation from 100 to 150 volts or 200 to 250 volts, and adequate r.f. filtering is introduced into the a.c. input circuit.

2 OPERATION

2.1 INSTALLATION

Unless otherwise specified, the Signal Generator is normally despatched with its valves in position and with its mains input circuit adjusted for immediate use with a 240-volt, 40- to 100-c/s mains supply. The instrument can be adjusted for operation from any other 40- to 100-c/s supply voltage in the ranges 200 to 250 and 100 to 150 volts. To check or alter the settings of the mains transformer tappings, the user should refer to MAINTENANCE - Section 4.3.

2.2 SWITCHING ON AND WARMING UP

Before switching ON, be quite sure that the instrument is correctly adjusted to suit the particular mains supply to which it is to be connected. The proceed as follows:-

(1) Connect the mains lead - stowed in the left-hand case-handle recess - to the mains supply socket.

(2) Switch ON by means of the SUPPLY switch; the red pilot lamp should now glow.

(3) Before proceeding further, allow a short time - say five minutes - to elapse for the internal circuits to warm up. If a particularly high standard of frequency stability is required, this time should be increased to about 30 minutes.

2.3 CONNECTING TO THE EQUIPMENT UNDER TEST

The r.f. output from the Signal Generator is derived via a permanently-attached coaxial cable fitted with a free plug; the cable is stowed in the right-hand case-handle recess.

The separate dual-output-impedance TERMINATING UNIT has a fixed-socket inlet which mates with the free plug on the output cable. The outlets of the TERMINATING UNIT are fixed sockets of the same type.

2.3 (continued)

The 20-dB ATTENUATOR PAD, available as an optional accessory for insertion between the output cable and the TERMINATING UNIT when low outputs are required, has a similar fixed socket at its input end and fixed plug at its output end.

The free plug, Belling-Lee Type L734/P, fitted to the output cable mates with the following types of Belling-Lee coaxial-socket connectors:-

Free Socket, Type L734/J
Fixed Socket, Type L604/S (ZC 29611)
Fixed Socket, Type L734/S
Free plug-to-socket adaptor, Type L616, (This item allows the mating of two free plugs)

The fixed sockets on the TERMINATING UNIT are Belling-Lee Type L734/S and mate with the following types of Belling-Lee coaxial-plug connectors:-

Free Plug, Type L734/P (ZC 36219)
Free Plug, Type L781/P

2.4 TUNING

The various aspects of tuning the Generator are dealt with in the following sections.

General tuning: Section 2.4.1.
Standardizing frequency against crystal oscillator: Section 2.4.2.
Use of incremental frequency controls: Section 2.4.3.
Interpolation of main frequency scales: Section 2.4.4.

2.4.1 General Tuning

The TF 995A/2 covers the range 1.5 to 220 Mc/s in five bands as follows:-

1.5	to 13.5	Mc/s
13.5	to 27	Mc/s
27	to 54	Mc/s
54	to 108	Mc/s
108	to 220	Mc/s

2.4.1 (continued)

The particular band required is selected by means of the RANGE switch. Rotation of the TUNE control varies the output frequency within the limits of the band selected, and moves the main dial relative to its cursor.

The Signal Generator has a built-in crystal calibrator, and the cursor of the main tuning dial is mounted so that its angular position relative to that of the dial is variable over a small arc by movement of a milled boss at the centre of the dial. This movable cursor enables the operator to standardize the frequency scale of the Signal Generator at any time; the cursor is used in conjunction with the crystal calibrator in the manner described in Section 2.4.2.

In addition to the RANGE switch and the TUNE control, the instrument is fitted with a directly-calibrated incremental-frequency control; the method of using this control is described fully in Section 2.4.3. Section 2.4.4 deals with the method of interpolating between main dial markings by means of the linearly calibrated dial on the TUNE control.

2.4.2 The Crystal Calibrator and its Use in Standardizing the Frequency Scale

(a) Introduction

The calibrator, or crystal oscillator, has a fundamental frequency of 333.3 kc/s, with an accuracy of 2 parts in 10^4, and is coupled to the basic 4.5- to 9.16-Mc/s r.f. oscillator which feeds the multiplier chain. Plugging a pair of high-resistance head telephones into the CRYSTAL CHECK jack socket automatically brings the calibrator circuit into use; with the aid of the headphones, the difference frequency between the basic oscillator and the harmonic multiples of the calibrator's 333.3 kc/s can be monitored aurally.

Because the outputs on the four higher-frequency bands are all derived directly from the multiplier chain, their frequencies have an exact integral relationship to the frequency of the basic oscillator. It follows, therefore, that setting the TUNE control to bring the basic-oscillator frequency to that of a crystal harmonic will also bring the frequency of the outputs from the multiplier chain to a known relationship with the crystal harmonic, and allow the frequency dial to be standardized with a high degree of accuracy.

2.4.2 (continued)

Outputs on the lowest-frequency, 1.5- to 13.5-Mc/s, band are not derived directly from the multiplier chain; their generation involves a heterodyne action between the 27- to 54-Mc/s multiplier and a 30-Mc/s fixed oscillator which is not locked to the basic oscillator. For this reason, although use is made of the crystal calibrator when setting up for 1.5- to 13.5-Mc/s outputs, the accuracy of standardization is of a lower order than that obtained on the four higher-frequency ranges.

(b) Check-Point Frequencies

The calibrator provides a total of 56 check points between 13.5 and 220 Mc/s; these check points occur as follows:-

13.5 - 27 Mc/s band:	At 14, 15, and 16 Mc/s, and every calibration point which is a multiple of 1 Mc/s, to 27 Mc/s.
27 - 54 Mc/s band:	At 28, 30, and 32 Mc/s, and every calibration point which is a multiple of 2 Mc/s, to 54 Mc/s.
54 - 108 Mc/s band:	At 56, 60, and 64 Mc/s, and every calibration point which is a multiple of 4 Mc/s, to 108 Mc/s.
108 - 220 Mc/s band:	At 112, 120, and 128 Mc/s, and every calibration point which is a multiple of 8 Mc/s, to 216 Mc/s.

(c) Standardization Procedure

As shown above, the calibrator allows the frequency scale to be checked at 14 different points on each of the above bands, and the adjustable cursor can be set to correspond exactly with any one of these points.

When the Signal Generator is to be used above 13.5 Mc/s to provide an output at a single spot frequency, or over a narrow band of frequencies, the cursor should be set up at the nearest crystal check point.

2.4.2 (continued)

When the Signal Generator is to be used over a wide range of frequencies, and it is inconvenient to reset the cursor for each material frequency change, or, alternatively, when using the 1.5- to 13.5-Mc/s band, the procedure is varied to reduce the mean error to a minimum. The method of standardizing the frequency scale for subsequent general use is as follows:-

(1) Set the INC. FREQ. control to zero.

(2) Set the RANGE switch to 13.5 - 27 Mc/s.

(3) Using the headphones plugged into the CRYSTAL CHECK jack socket, tune the main dial to a crystal check point near the centre of the band; e.g., 20 Mc/s.

When using the calibrator, the MOD SELECTOR must be set to a position other than INT MOD - F.M. or EXT MOD - F.M. This ensures that the variable oscillator is not being frequency modulated - a condition which prevents precise setting of the TUNE control for the lowest-frequency beat note in the headphones, since it gives rise to a fluctuating tone.

After using the calibrator, the Signal Generator can, of course, be subsequently set up for f.m. without invalidating any frequency calibration previously given by use of the calibrator.

(4) Adjust the milled boss in the centre of the dial to bring the cursor exactly in line with the calibration mark corresponding to the crystal check point.

If the Signal Generator has been out of use for some time, it may be necessary to use a coin in the slot provided in order to rotate the milled boss.

(5) Check the calibration accuracy at several crystal check points both above and below the check point at which the cursor was set in (4) above.

(6) Readjust the cursor setting to equalize the errors over the band; e.g., it might be found that, with the frequency scale indication correct at 20 Mc/s, the indication was high at both 15 and 25 Mc/s

2.4.2 (continued)

- in such a case, the errors would be equalized by making the indication a little low at 20 Mc/s, and thus not so high at 15 and 25 Mc/s.

It will be noted that, in the above procedure, the frequency scale is standardized on the 13.5- to 27-Mc/s band. This band is specified since its corresponding scale calibrations occupy the longest arc on the dial. The dial can therefore be read with a high degree of discrimination on this band and the correct cursor setting most easily determined. Once the frequency scale has been standardized on the 13.5- to 27-Mc/s band, the cursor is correctly set to give the minimum mean error on the other three direct-multiple bands. It is also correctly set for the 1.5- to 13.5-Mc/s band.

When standardized in this way, the main tuning dial indication for frequencies above 13.5 Mc/s is accurate to at least 1%, and will generally be within 0.5%; for frequencies below 13.5 Mc/s, the average error does not exceed 3%.

2.4.3 The Incremental Frequency Control

This control provides a convenient means of producing small, accurately known changes in carrier frequency. Since it is not connected directly to the r.f. oscillator, either mechanically or electrically, but operates by varying the d.c. voltage at the grid of the reactor valve, the control is completely free from any sort of backlash. This attribute, together with the directly calibrated scale, renders the control very suitable for bandwidth or similar measurements.

To use the controls proceed as follows:-

(1) With the INC. FREQ. dial set to its centre zero position, tune the Signal Generator to the centre frequency of the equipment under test by means of the TUNE control.

(2) Rotate the INC. FREQ. control by the amount necessary to produce the required frequency shift or the required change in response depending on the method of measurement.

The scale of the INC. FREQ. dial is direct-reading on the 13.5- to 27-Mc/s band. For each of the other bands, a multiplying

2.4.3 (continued)

factor must be applied, the appropriate factor for each frequency band is engraved on the front panel adjacent to the RANGE switch marking. The multiplying factors are also given below in TABLE 1.

TABLE 1

RANGE switch setting (Mc/s)	Total coverage of INC. FREQ. control (kc/s)	Multiply INC. FREQ. dial readings by
1.5 - 13.5	±100	2
13.5 - 27	±50	1
27 - 54	±100	2
54 - 108	±200	4
108 - 220	±400	8

2.4.4 The Interpolating Dial

The TUNE control knob is fitted with a small dial calibrated linearly from 0 to 100 over its total circumference and makes approximately 17 revolutions as the main dial is turned through its complete angle of rotation.

This dial may be used to subdivide linearly any portion of the frequency coverage on any band in order to tune accurately to a frequency above 13.5 Mc/s which does not coincide with a crystal check point. The method of using the dial for this purpose is described in the following instructions:-

(1) Set the INC. FREQ. control to zero.

(2) Set the RANGE switch to whichever of the four higher-frequency bands includes the required frequency.

2.4.4 (continued)

(3) Tune the Signal Generator to the nearest crystal check point below the required frequency, identify the point with the aid of the CRYSTAL CHECK oscillator and note the interpolating dial reading.

(4) Tune the Signal Generator to the nearest crystal check point above the required frequency and note the change of reading of the interpolating dial. It is important that the total change is noted when the dial is turned through more than one revolution.

The relationship should be determined between the crystal check points which embrace the particular section of the frequency band over which incremental variations are to be made. Also, the relationship should be redetermined for each different section of the frequency band, since it varies, not only from band to band, but also for different sections of any one band.

(5) From the difference in frequency between the two crystal check points, and the total interpolating dial divisions traversed, calculate the frequency change per interpolating dial division.

(6) With the aid of the headphones, reset the main tuning dial to the crystal check point below the required frequency.

(7) Rotate the TUNE control so that the interpolating dial traverses the correct number of divisions to give the required frequency.

It is recommended that the required frequency should always be approached from the low-frequency side in order to eliminate the possibility of error due to backlash.

The following example illustrates the use of the interpolating dial to obtain an output from the instrument at an accurate frequency of 74.25 Mc/s.

Example: With the TUNE control set to the crystal check point at 72 Mc/s, the interpolating dial reading was 17. With the TUNE control set to the crystal check point at 76 Mc/s the new reading on the auxiliary dial was 40. The total number of interpolating dial divisions traversed was 123, the dial

2.4.4 (continued)

having rotated through slightly more than one revolution for the frequency change of 4 Mc/s, i.e. 4,000 kc/s. In this case, a change of 1 division on the interpolating dial corresponded, between 72 and 76 Mc/s, to a nominal frequency change of

$$\frac{4000}{123} = 32.5 \text{ kc/s}$$

Therefore, by starting from the original auziliary dial setting at 72 Mc/s (72,000 kc/s) the required frequency of 74.25 Mc/s (74,250 kc/s) was obtained by rotating the auxiliary dial through

$$\frac{74,250 - 72,000}{32.5} = \frac{2250}{32.5} = 69 \text{ divisions}$$

The interpolating dial can also, of course, be calibrated in kc/s per division for any portion of the 1.5- to 13.5-Mc/s band. Crystal check points cannot be used on this band, but the movement of the auxiliary dial for any frequency interval can be determined against the appropriate main dial calibration markings, and accurate interpolation between these marks carried out as previously described for the higher-frequency ranges.

2.5 SETTING UP FOR CONTINUOUS WAVE OR MODULATED OUTPUT

The Signal Generator includes facilities which allow the following types of r.f. output to be obtained:-

(1) Continuous Wave (see Section 2.5.1)

(2) Amplitude Modulated (see Section 2.5.2), variable to 50% depth,

  (a) from the internal a.f. oscillator at 1,000 c/s,

  (b) from an external sine-wave source, within the range 50 c/s to 10 kc/s.

(3) Frequency Modulated (see Section 2.5.3), variable to maximum frequency deviations ranging from 25 kc/s to 600 kc/s,

2.5 (continued)

(a) from the internal a.f. oscillator at 1,000 c/s;

(b) from an external sine-wave source, within the range 50 c/s to 15 kc/s.

(4) Simultaneously Frequency and Amplitude Modulated (see Section 2.5.4), the Amplitude Modulation being obtained from the internal a.f. oscillator, and the Frequency Modulation from an external source as (3) (b), above.

When setting up for amplitude or frequency modulation as described in Sections 2.5.2 and 2.5.3, it may be observed that, with the METER READS key held to either A.M. or F.M., as applies, the apparent modulation as measured on external apparatus is less than that indicated on the meter. This is quite in order; the meter indicates the modulation which will be obtained when the switch is returned to its central position and the meter reverts to its normal function of monitoring the r.f. level.

2.5.1 Continuous Wave

(1) Set the MOD SELECTOR switch to C.W.

(2) Adjust the SET CARRIER control to bring the meter pointer to the SET R.F. mark.

2.5.2 Amplitude Modulation

(a) From the internal oscillator

(1) Set the MOD SELECTOR switch to INT MOD - A.M.

(2) Adjust the SET CARRIER control to bring the meter pointer to the SET R.F. mark.

(3) With the METER READS key switch held in the A.M. position, adjust the SET MOD control to the required modulation depth, as indicated on the top scale of the panel meter. Amplitude modulation is variable to a maximum depth of 50%.

2.5.2 (continued)

(4) Release the METER READS key switch and, if necessary, repeat (2) above.

(b) From an external a.f. source

(1) Set the MOD SELECTOR switch to EXT MOD - A.M.

(2) Adjust the SET CARRIER control to bring the meter pointer to the SET R.F. mark.

(3) Connect the external modulation source to the EXT MOD and E terminals.

(4) With the METER READS key switch held in the A.M. position, adjust the SET MOD control to the required modulation depth, as indicated on the top scale of the panel meter. With the SET MOD control at maximum, an input of approximately 15 volts r.m.s. is required at the EXT MOD and E TERMINALS to produce 30% modulation depth within the modulation frequency range 50 c/s to 10 kc/s.

(5) Release the METER READS key switch and, if necessary, repeat (2) above.

2.5.3 Frequency Modulation

In addition to the MOD SELECTOR switch, there are three other controls concerned in setting up the carrier deviation when the output from the Signal Generator is to be frequency modulated. These controls are the continuously-variable SET MOD potentiometer, the DEVIATION RANGE switch, and the DEVIATION - NORMAL/HIGH switch. When the METER READS key switch is held to F.M., the panel meter indicates deviation. The meter has two deviation scales: one calibrated from 0 to 25 kc/s, and the other from 0 to 75 kc/s.

With the DEVIATION - NORMAL/HIGH switch set to NORMAL, the meter scale appropriate to the setting of the DEVIATION RANGE switch is used and the deviation is as indicated by the meter for all settings of the carrier-frequency range switch.

2.5.3 (continued)

With the DEVIATION-NORMAL/HIGH switch set to HIGH, the deviation obtained on the 13.5- to 27-Mc/s band is the same as with the switch set to NORMAL. For all other carrier-frequency bands the deviation is increased and the meter readings - again, taken on the scale appropriate to the settings of the DEVIATION RANGE switch - must be multiplied in accordance with TABLE 2 below.

TABLE 2

Carrier frequency RANGE switch setting (Mc/s)	DEVIATION RANGE switch setting (kc/s)	DEVIATION - NORMAL/HIGH switch is set to HIGH	
		Multiply meter reading by	Maximum deviation obtainable (kc/s)
1.5 - 13.5	25	2	50
	75	2	150
13.5 - 27	25	1	25
	75	1	75
27 - 54	25	2	50
	75	2	150
54 - 108	25	4	100
	75	4	300
108 - 220	25	8	200
	75	8	600

The example given overleaf shows the method of determining the meter reading for a required deviation which is greater than 75 kc/s and thus necessitates setting the DEVIATION - NORMAL/HIGH switch to HIGH.

2.5.3 (continued)

Example: A deviation of 160 kc/s is required at a carrier frequency of 80 Mc/s. The carrier frequency lies within the 54- to 110-Mc/s band. The meter multiplying factor for this band is 4; therefore, for 160 kc/s deviation, the meter should be set (by means of the SET MOD control) to read

$$\frac{160}{4} = 40 \text{ kc/s}$$

Do this on the bottom scale of the meter with the DEVIATION RANGE switch set to 75 kc/s.

(a) F.M. from the internal oscillator

(1) Set the MOD SELECTOR switch to INT MOD - F.M.

(2) Set the DEVIATION RANGE switch as required. If, at carrier frequencies less than 13.5 Mc/s, or greater than 27 Mc/s, more than 75 kc/s deviation is required, set the DEVIATION - NORMAL/HIGH switch to HIGH. (Deviations greater than 75 kc/s are not obtainable on the 13.5- to 27-Mc/s carrier-frequency band, the maximum deviations obtainable on the other carrier-frequency bands are given earlier in TABLE 2).

(3) Adjust the SET CARRIER control to bring the meter pointer to the SET R.F. mark.

(4) With the METER READS key switch held to F.M., adjust the SET MOD control until the required deviation is indicated on the panel meter; read the meter on its middle scale when the DEVIATION range switch is set to 25 kc/s, and read on the lower scale when the switch is set to 75 kc/s. If the DEVIATION - NORMAL/HIGH switch is set to HIGH, the meter readings must be multiplied by the appropriate factor given in TABLE 2.

(5) Release the METER READS key switch and, if necessary, repeat (4) above.

2.5.3 (continued)

(b) F.M. from an external source

(1) Set the MOD SELECTOR switch to EXT MOD - F.M.

(2) Set the DEVIATION RANGE switch as required. If at carrier frequencies less than 13.5 Mc/s, or greater than 27 Mc/s, more than 75 kc/s deviation is required, set the DEVIATION - NORMAL/HIGH switch to HIGH. (Deviations greater than 75 kc/s are not obtainable on the 13.5- to 27-Mc/s carrier-frequency band; the maximum deviations obtainable on the other carrier-frequency bands are given earlier in TABLE 2).

(3) Adjust the SET CARRIER control to bring the meter pointer to the SET R.F. mark.

(4) Couple the external modulation source to the EXT MOD and E terminals.

(5) With the METER READS key switch held to F.M., adjust the SET MOD control until the required deviation is indicated on the panel meter; read the meter on its middle scale when the DEVIATION RANGE switch is set to 25 kc/s, and read on the lower scale when the switch is set to 75 kc/s. If the DEVIATION - NORMAL/HIGH switch is set to HIGH, the meter readings must be multiplied by the appropriate factor given in TABLE 2.

For any settings of the DEVIATION RANGE and DEVIATION - NORMAL/HIGH switches, and within the modulation frequency range 50 c/s to 15 kc/s, approximately 25 volts r.m.s. is required between the EXT MOD and E terminals for full deviation. With respect to 1 kc/s, the frequency characteristic of the modulation system is flat to within ±1 dB from 50 c/s to 15 kc/s.

2.5.4 Simultaneous Frequency and Amplitude Modulation

(1) Set up the required depth of amplitude modulation as detailed in Section 2.5.2 (a).

2.5.4 (continued)

(2) Leaving the MOD SELECTOR switch at INT MOD - A.M., and without altering the setting of the SET MOD control, set up the required deviation in a similar manner to that detailed in Section 2.5.3 (b); in this case, adjust the amount of deviation by variation of the audio input from the external modulation source.

2.6 R.F. OUTPUT ARRANGEMENTS

Five factors affect the output level from the Signal Generator; these factors are:

(a) The SET CARRIER control whose setting determines the input level to the attenuator cascade.

(b) The "coarse" or OUTPUT VOLTAGE attenuator.

(c) The "fine" or MULTIPLY BY attenuator.

(d) The TERMINATING UNIT which plugs on the end of the output cable from the fine attenuator.

(e) ATTENUATOR PAD Type TM 4736, which is an optional accessory designed for insertion between the output cable and TERMINATING UNIT when especially low output levels are required.

The SET CARRIER control is adjusted in conjunction with the panel meter; with the METER READS key switch in its central position, the panel meter forms part of a crystal voltmeter which monitors the input to the coarse attenuator. The panel meter has three main marks on its scale; these marks are minus 1 dB, SET R.F., and plus 1 dB respectively. Normally, the SET CARRIER control should be adjusted to bring the meter pointer to the SET R.F. mark.

Four 20-dB steps give the coarse or OUTPUT VOLTAGE attenuator a total range of 80 dB; each setting of the attenuator control has markings in red and in white. The red markings are in terms of decibels relative to 1 μV; the white markings are directly in units of voltage.

2.6 (continued)

Ten 2-dB steps give the fine or MULTIPLY BY attenuator a total range of 20 dB; each setting of the attenuator control has markings in red and white, the red markings being in terms of decibels relative to 1 μV, and the white markings, multiplying factors for the white voltage markings on the coarse attenuator.

Both attenuators have a characteristic impedance of 75 ohms and, "looking into" the coaxial plug at the end of the output cable, the instrument appears as a generator with a source impedance of 75 ohms.

The TERMINATING UNIT is, essentially, a 6-dB attenuator pad; "looking into" its input socket, the TERMINATING UNIT presents an impedance of 75 ohms, while the two outlets present impedances of 52 and 75 ohms respectively.

The ATTENUATOR PAD has a characteristic impedance of 75 ohms and provides an optional, additional, 20-dB attenuation of the output signal.

It should be noted particularly that the r.f. output controls on the Signal Generator are calibrated in terms of source e.m.f. or open-circuit output voltage. The significance of quoting the output of a signal generator in this way will be apparent when it is remembered that one of the primary functions of a signal generator is to simulate a received signal as it would come from an aerial.

To take a simple case - that in which a 75-ohm receiver is fed from a 75-ohm dipole, the e.m.f. induced in the aerial is shared between its inherent 75-ohm radiation resistance and the matched 75-ohm receiver input. Clearly, when the same receiver is fed from a signal generator, the corresponding signal strength is given by the source e.m.f. of the signal generator, and not by the on-load p.d. at the receiver terminals.

2.6.1 Outputs from 1 μV to 100 mV at 52 and 75 ohms

It is intended that the Signal Generator should normally be used with the SET CARRIER control adjusted to bring the meter pointer to the SET R.F. mark; with the TERMINATING UNIT coupled directly to the output cable; and, without the ATTENUATOR PAD Type TM 4736.

2.6.1 (continued)

Used in this way, the Signal Generator should be regarded as a source of zero impedance in series with a resistance of either 75 ohms or 52 ohms, the open-circuit output level, or source e.m.f., being variable in 2-dB steps from 1 μV to 100 mV and being given

(a) directly in terms of decibels relative to 1 μV, by the sum of the "red" settings of the OUTPUT VOLTAGE and MULTIPLY BY attenuators;

(b) directly in voltage, by the product of the "white" settings of the OUTPUT VOLTAGE and MULTIPLY BY attenuators.

The plus 1-dB and minus 1-dB marks on the panel meter allow interpolation between the 2-dB steps of the MULTIPLY BY attenuator. Setting the meter pointer to either the plus 1-dB or minus 1-dB mark increases or decreases the input to the attenuator cascade by 1 decibel. Thus, using the SET CARRIER control and panel meter in conjunction with the OUTPUT VOLTAGE and MULTIPLY BY attenuators, the output level from the Signal Generator can be varied in 1-dB steps over the range 0 to +100 dB relative to 1 μV.

It should be noted that the "white" voltage indication given by the attenuator controls is not directly applicable when the meter is set to other than the SET R.F. mark; with the meter at minus 1 dB, the source e.m.f. at the TERMINATING UNIT outlets is 0.89 of the indicated voltage; with the meter at plus 1 dB, the source e.m.f. is 1.12 of the indicated voltage.

2.6.2 Outputs from 2 μV to 200 mV at 75 ohms only

With the TERMINATING UNIT detached and with the meter at the SET R.F. mark, the output level obtained directly from the plug at the end of the r.f. output cable is variable in the range 2 μV to 200 mV and is derived via a source impedance of 75 ohms.

Under these conditions, the open-circuit level, or source e.m.f., in terms of decibels relative to 1 μV is obtained by adding 6 dB to the sum of the meter reading and the "red" indications of the OUTPUT VOLTAGE and MULTIPLY BY attenuators; the source e.m.f. is given directly in voltage by doubling the product of the "white" indications of the OUTPUT VOLTAGE and MULTIPLY BY attenuators.

2.6.3 Outputs from 0.1 μV to 10 mV at 52 and 75 ohms

With the TERMINATING UNIT coupled to the r.f. output cable via the optional 20-dB ATTENUATOR PAD and with the meter at the SET R.F. mark, the output level from the TERMINATING UNIT is variable in the range 0.1 μV (nominal) to 10 mV.

In this case, the source e.m.f. in terms of decibels relative to 1 μV is obtained by subtracting 20 dB from the sum of the meter reading and the "red" indications of the OUTPUT VOLTAGE and MULTIPLY BY attenuators; the source e.m.f. is given directly in voltage by dividing the product of the "white" indications of the OUTPUT VOLTAGE and MULTIPLY BY attenuators by 10.

2.6.4. Output in terms of voltage developed across an external load

For some particular applications, it may be desired to work not in terms of source e.m.f. as indicated by the meter and attenuator controls, but in terms of actual voltage developed across the external load. This on-load, or terminal voltage, is given by the expression

$$V_L = E \times \frac{Z_L}{Z_O + Z_L} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where V_L = actual voltage developed across the external load.

E = the source e.m.f. of the Signal Generator.

Z_L = the impedance of the external load.

Z_O = the source impedance of the Signal Generator;
(with the TERMINATING UNIT in use, Z_O = 75 or 52 Ω;
with the TERMINATING UNIT removed, Z_O = 75 Ω)

The expression is based on the assumption that the external load impedance Z_L is essentially resistive. Where Z_L is not essentially resistive, it may be necessary for the user to revise the expression to take account of the reactive component of the load.

A series of multiplying factors, which can be used to convert from source e.m.f. to actual voltage developed across an external resistive load, and which have been derived with the aid of the above expression, are given in TABLE 3 for a selection of typical load values.

2.6.4 (continued)

TABLE 3

External load impedance in ohms	Approximate multiplying factor to convert from source e.m.f. to actual voltage developed across an external resistive load	
	Z_O = 75 Ω	Z_O = 52 Ω
10	0.12	0.16
20	0.21	0.28
30	0.29	0.36
40	0.35	0.43
50	0.4	0.49
52	0.41	0.5
60	0.44	0.53
70	0.48	0.57
75	0.5	0.59
80	0.51	0.61
100	0.57	0.65
150	0.67	0.74
200	0.73	0.79
300	0.8	0.85
500	0.87	0.9

2.6.5 Matching to external loads other than 52 or 75 ohms

The TERMINATING UNIT supplied with the Signal Generator allows r.f. outputs to be obtained from a source impedance of either 52 or 75 ohms.

If the equipment under test has an input impedance of other than 52 or 75 ohms, and if it is required to present the equipment with a signal derived from a matched source, then it is necessary to modify the output arrangements of the Signal Generator. The simple modifications required are described in sub-sections (a) and (b) which follow.

In these sub-sections it is assumed that the TERMINATING UNIT is in circuit, and that the 20-dB ATTENUATOR PAD is out of circuit.

2.6.5 (continued)

(a) External load less than that of the TERMINATING UNIT outlet in use.

The impedance presented to the load can be made equal to the load impedance by shunting the TERMINATING UNIT outlet with a single resistor, R_p, where

$$R_p = \frac{Z_O \times Z_L}{Z_O - Z_L} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

and where Z_O = the source impedance of the Signal Generator at the TERMINATING UNIT outlet in use.

Z_L = the impedance of the external load.

Under these conditions, the relationship between E_{SG}, the e.m.f. indicated by the attenuator controls on the Signal Generator, and E_E, the effective source e.m.f. presented to the external load, is given by the expression

$$E_{SG} = E_E \times \frac{R_p + Z_O}{R_p} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Example: It is required to provide a signal of 25 μV effective source e.m.f. at a source impedance of 20 ohms.

Since the new source impedance is to be 20 ohms, the output is taken from the 52-ohm outlet on the TERMINATING UNIT, the 52-ohm outlet being chosen in preference to the 75-ohm outlet to obtain the minimum reduction from E_{SG} to E_E.

From expression (2), the value of R_p to be connected in parallel with the 52-ohm outlet of the TERMINATING UNIT is

$$\frac{52 \times 20}{52 - 20} = 32.5\ \Omega$$

From expression (3), the attenuator controls on the Signal Generator should be set to indicate

$$25 \times \frac{32.5 + 52}{32.5} = 65\ \mu V$$

2.6.5 (continued)

The attenuators cannot be set to indicate exactly 65 μV and they should therefore be set to 63 μV - the setting nearest to the required value for E_{SG}. 63 μV is approximately -0.3 dB relative to 65 μV and, if desired, the user may obtain an E_{SG} nearer to 65 μV by adjustment of the SET CARRIER control to bring the meter pointer to an estimated +0.3 dB.

As a result of shunting the output of the TERMINATING UNIT with 32.5 ohms and setting the attenuator controls in the manner described, the equipment under test is fed from a source whose effective output impedance is 20 ohms and whose effective source e.m.f. is 25 μV; the actual voltage developed across the input impedance of the equipment under test is, of course, 12.5 μV.

(b) External load greater than that of the TERMINATING UNIT outlet in use.

The impedance presented to the load can be made equal to the load impedance by connecting a single resistor, R_S, in series with the Signal Generator output. The value of R_S is given by the expression

$$R_S = Z_L - Z_O \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

where Z_L = the impedance of the external load.

Z_O = the source impedance of the Signal Generator at the TERMINATING UNIT outlet in use.

Under these conditions, the effective source e.m.f. (E_E) of the Signal Generator and series resistor combined, equals the source e.m.f. (E_{SG}) of the Signal Generator alone,

$$\text{i.e., } E_{SG} = E_E \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Example: It is required to provide a signal of 10 μV effective source e.m.f. at a source impedance of 300 ohms.

Since the new output impedance is greater than either 52 or 75 ohms, there is no advantage to be gained by using one of the TERMINATING UNIT

2.6.5 (continued)

outlets in preference to the other; in this example it is assumed that the 75-ohm outlet is used.

From expression (4) the value of R_S to be connected in series with the "live" connection between the Signal Generator and the equipment under test, is

$$300 - 75 = 225\ \Omega$$

From expression (5), the attenuators on the Signal Generator should be set to indicate

$$10\ \mu V$$

In this way, the equipment under test is fed from a source whose effective impedance is 300 ohms and whose effective source e.m.f. is 10 μV; the actual voltage developed across the input impedance of the equipment under test is, of course, 5 μV.

2.6.6 Matching to balanced loads

The preceding Sections dealing with r.f. output arrangements are based on the supposition that the equipment being fed from the Signal Generator has an unbalanced input circuit.

With certain types of equipment, the input circuit is in the form of a balanced winding; such equipment can be fed from the unbalanced output of the Signal Generator by interposing two loading resistors between the TERMINATING UNIT outlet and the ends of the balanced input winding.

One resistor, R_1, is connected in series between the earth connection of the TERMINATING UNIT outlet in use and one side of the balanced winding; the other resistor, R_2, is connected in series between the "live" connection of the TERMINATING UNIT outlet in use and the other side of the balanced winding.

Values for R_1 and R_2 may be computed from the following expressions

$$R_1 = \frac{Z_{LB}}{2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (6)$$

2.6.6 (continued)

$$R_2 = \frac{Z_{LB}}{2} - Z_O \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

where Z_{LB} = the total line-to-line impedance of the balanced winding.

Z_O = the source impedance of the Signal Generator at the TERMINATING UNIT outlet in use.

With the equipment under test and the TERMINATING UNIT of the Signal Generator interconnected via R_1 and R_2 as described above, the source e.m.f. (E_{SG}) indicated by the Signal Generator controls is equal to the effective line-to-line source e.m.f. (E_E) seen by the equipment under test.

Example It is required to match the 75-ohm outlet to a balanced winding whose total line-to-line impedance is 200 ohms.

From expression (6), the value of R_1 is

$$\frac{200}{2} = 100\,\Omega$$

From expression (7) the value of R_2 is

$$\frac{200}{2} - 75 = 25\,\Omega$$

R_1 is connected in series with the earth connection of the TERMINATING UNIT and one side of the balanced winding; R_2 is connected in series with the "live" connection between the TERMINATING UNIT and the other side of the balanced winding.

2.7 SYNCHRONIZING SIGNAL

A 1,000-c/s sine wave signal, derived from the internal a.f. oscillator, is available between the SYNC and E terminals of the instrument when the MOD SELECTOR switch is set at either of the INT MOD positions. This signal has an open-circuit level of the order of 100 volts and is derived via a source impedance of approximately 250 kΩ.

2.7 (continued)

When an output from the equipment under test is being viewed on a cathode-ray oscilloscope, it will often be found convenient to lock the c.r.o. time base directly with the SYNC signal rather than with the actual signal being viewed.

The SYNC output can, of course, also be used when an audio frequency signal is required for the equipment under test.

3 ABRIDGED OPERATING INSTRUCTIONS

When the user is familiar with the principles and techniques of operation detailed in Section 2 of this handbook, the following abridged operating instructions may be found convenient.

Carrier Frequency Range:	1.5 to 220 Mc/s
Source Impedance:	Without TERMINATING UNIT, 75 Ω With TERMINATING UNIT, 52 and 75 Ω
Open-circuit Output Voltage:	Without TERMINATING UNIT, 200 mV With TERMINATING UNIT, 100 mV
Modulation Frequency Range:	Internal F.M. and A.M., 1,000 c/s. External F.M., 50 c/s to 15 kc/s. External A.M., 50 c/s to 10 kc/s.
Modulation Range:	F.M., DEVIATION switch at NORMAL, 0 to 25 kc/s and 0 to 75 kc/s; DEVIATION switch at HIGH, varies with frequency range up to 600 kc/s on 108 to 220 Mc/s band. A.M., 0 to 50%.
Power Supply:	100 to 150 volts, 40 to 100 c/s; 200 to 250 volts, 40 to 100 c/s.

Check correctness of mains transformer tappings before use

STANDARDIZING THE FREQUENCY SCALE

Switch mains ON and set RANGE MC/S switch to 13.5 - 27; with MOD SELECTOR switch set to other than INT MOD - F.M. or EXT MOD - F.M., and using headphones plugged into CRYSTAL CHECK socket, tune main dial to crystal check point near centre of band. Bring movable cursor in line with dial calibration corresponding to crystal check point. Check accuracy of frequency indication above and below point to which cursor was originally set, equalize errors over band by readjusting cursor.

For further details, refer to Section 2.4.2.

3 (continued)

TUNING

Set RANGE MC/S switch to band required; rotate TUNE control until cursor indicates required frequency. For higher frequency-accuracy, compute relationship of frequency change to change in auxiliary dial setting between crystal check points or scale markings embracing required frequency. Starting from selected point below required frequency, rotate TUNE control so that incremental dial traverses calculated number of divisions.

For further details, refer to Sections 2.4.1 and 2.4.4.

INCREMENTAL FREQUENCY ADJUSTMENT

Make small carrier changes by means of INC FREQ control, using multiplying factors as shown on front panel.

For further details, refer to Section 2.4.3.

C.W. OPERATION

With MOD SELECTOR switch set to C.W., adjust SET CARRIER to bring meter pointer to SET R.F.; adjust step attenuators to obtain required output level.

For further details, refer to Section 2.5.1.

AMPLITUDE MODULATION

INTERNAL:

With MOD SELECTOR switch at INT MOD - A.M., adjust SET CARRIER to bring meter pointer to SET R.F. With METER READS switch at A.M., adjust SET MOD to bring meter pointer to required modulation depth. Release METER READS switch and, if necessary, readjust SET CARRIER; adjust step attenuators to obtain required output level.

3 (continued)

EXTERNAL:

As for internal, except that MOD SELECTOR switch is set to EXT MOD - A.M., and external signal injected between EXT MOD and E terminals. Approximately 15 volts r.m.s. (50 c/s to 10 kc/s) is required to produce 30% modulation.

For further details, refer to Section 2.5.2.

FREQUENCY MODULATION

INTERNAL:

With MOD SELECTOR switch at INT MOD - F.M., adjust SET CARRIER to bring meter pointer to SET R.F. With DEVIATION - NORMAL/HIGH switch at NORMAL, and METER READS switch at F.M., adjust SET MOD to bring meter pointer to required deviation on meter scale appropriate to DEVIATION RANGE switch setting. (For deviations greater chan 75 kc/s, set DEVIATION - NORMAL/HIGH switch to HIGH and multiply meter readings by factor given in TABLE 2, Section 2.5.3). Release METER READS switch and, if necessary, readjust SET CARRIER; adjust step attenuators to obtain required output level.

EXTERNAL:

As for internal, except that MOD SELECTOR switch is set to EXT MOD - F.M. and external signal injected between EXT MOD and E terminals. Approximately 25 volts r.m.s. (50 c/s to 15 kc/s) is required to produce full deviation.

For further details, refer to Section 2.5.3.

SIMULTANEOUS FREQUENCY AND AMPLITUDE MODULATION

Set up as for AMPLITUDE MODULATION, INTERNAL. Then, with MOD SELECTOR switch, still set at INT MOD - A.M., apply external signal (50 c/s to 15 kc/s) between EXT MOD and E terminals. Adjust level of external signal to produce required deviation; do not readjust SET MOD control.

For further details, refer to Section 2.5.4.

4 MAINTENANCE

4.1 GENERAL

The following items (for details see CONTENTS, page iv) are included in this handbook to assist in the maintenance of the Signal Generator Type TF 995A/2:-

Block Schematic Diagram.
Complete Circuit Diagram.
Component Layout Illustrations.
Spares Ordering Schedule with Circuit References.
Valve Replacement Data Sheets.

Section 1, DESCRIPTION, of this handbook deals with the internal circuits of the Signal Generator and is intended to be read in conjunction with the Block Schematic Diagram; it is strongly recommended that the user should familiarize himself with the principles described in Section 1, and illustrated in the Diagram, before commencing the adjustment or replacement of component parts of the instrument.

The complete Circuit Diagram shows all the electrical components contained in the instrument. The description of these components - their type, value, rating, etc. - is given in the Spares Ordering Schedule; the Schedule also lists certain selected mechanical components.

The physical location of the electrical components is shown on the Component Layout Illustrations.

4.2 REMOVAL OF CASE

To remove the Signal Generator case:-

(1) Remove the screw securing the small plate in the left-hand side pocket*; the mains lead is cleated to the case by means of this plate.

(2) Extract the eight screws from around the edge of the front panel.

* On earlier models, this plate is not fitted and, instead, the mains lead should be fed through the hole in the back of the pocket as the instrument is withdrawn from its case.

4.2 (continued)

(3) Pull the instrument clear of its case and disconnect the six-way interconnecting cable from the power unit chassis.

(4) Detach the screw, from the inside of the case, which holds the cleating plate for the r.f. output cable to the right-hand side pocket.

4.3 MAINS INPUT ARRANGEMENTS

The instrument is fitted with a mains transformer which has a double-wound primary; each primary section is tapped and the two sections can be connected in series-parallel for 100- to 150-volt operation or in series for 200- to 250-volt operation.

The 100- to 150-volt or the 200- to 250-volt range is selected by links on the coil of the transformer. Selection of intermediate voltages within either range is made by means of fly leads on the transformer tags. These tags are common to both ranges and are, therefore, annotated with two voltages; the applicable voltage depends on the position of the range links.

One fly lead must always be connected to either the '0' or the '10' tag; the other is connected to the tag whose voltage, added to 0 or 10 as appropriate, equals the mains supply voltage. Do not connect the fly leads to the tags marked TAP A or TAP B.

In order to examine the connections to the transformer and, if necessary, make adjustments, the instrument must be removed from its case in the manner described in section 4.2. With the instrument out of its case, the transformer (Reference T4 on the Circuit Diagram and Component Layout Illustration MP 995A/2-8) is immediately accessible.

For Supply Voltages within the Range 200 to 250 volts, the tags on the transformer MUST be linked in the following manner:-

"TAP A" to "TAP B"

For Supply Voltages within the Range 100 to 150 volts, the tags on the mains transformer MUST be linked in the following manner:-

'0' to 'TAP B'
'100/200' to 'TAP A'

4.3 (continued)

On earlier models, the mains transformer is of slightly different mechanical construction. It is identified by having a mains-tapping plate fixed to its rear edge. Attached to this panel is a pierced reference plate which is reversible and marked with a selection of voltages. On one side of the plate, the voltages are applicable to the 100- to 150-volt range; on the other side, to the 200- to 250-volt range.

The two sections of the primary are connected together by means of links soldered between tags, numbered 1-2-3-4, on an insulated strip at the front of the transformer.

For 200- to 250-volt operation, link tag 2 to tag 3.

For 100- to 150-volt operation, link tag 1 to tag 2 and tag 3 to tag 4.

4.4 ACCESS TO ENCLOSED SUB-ASSEMBLIES

General tests or some peculiarity in the performance of the Signal Generator may suggest the desirability of inspecting the interior of one of the enclosed sub-assemblies which form part of the instrument. Any of these sub-assemblies can be dismantled by the appropriate procedure as detailed in the following sections.

4.4.1 R.F. Unit

To remove the screening cover from the r.f. unit:

(1) With the instrument removed from its case, lay it on its face.

(2) Extract the two screws which secure the screening cover of the r.f. unit in position.

(3) Grip the sides of the screening cover and draw it off; the cover is held by earthing contact springs and will consequently offer some resistance to removal.

4.4.2 MULTIPLY BY Attenuator

A view of the MULTIPLY BY (fine) attenuator with the screening cover removed is shown in the Component Layout Illustration MP 995A/2-7. To dismantle the attenuator:

(1) Remove the attenuator screening cover after extracting the single securing screw.

(2) Remove the front-panel control knob after slackening the two grub screws which secure it to its associated spingle.

(3) Detach the main body of the attenuator from the front panel by extracting five screws; three of these screws are visible on removal of the control knob as in (2) above; the two remaining screws are located immediately above the 8-dB and 12-dB panel markings respectively.

With the attenuator thus detached, it remains coupled to the body of the instrument by two coaxial leads; these leads are normally long enough to permit inspection and, if necessary, replacement of the attenuator resistors without completely disconnecting the attenuator.

Reassemble the attenuator in the reverse order to that detailed above.

4.4.3 OUTPUT VOLTAGE Attenuator and Monitor Crystal X2

In addition to the actual attenuator components, the r.f. monitor crystal, X2, and its associated filter components are mounted in the OUTPUT VOLTAGE attenuator casing. When dismantling the attenuator, the user should refer to Component Layout Illustration MP 995A/2-7. Access to the crystal, X2, resistors R71 and R72, and capacitors C88, C89 and C90 can be obtained by removing the cover of the attenuator in the following manner:

(1) Disconnect R70 from the small insulated spigot projecting through the cover of the attenuator.

(2) Remove the central securing screw and lift the screening cover clear of the attenuator body.

4.4.3 (continued)

To obtain access to the attenuator resistors, R73 to R82, detach the attenuator from the front panel of the Signal Generator in the following manner:-

(3) Remove the control knob by slackening the two grub screws securing it to its spindle.

(4) Extract the five fixing screws securing the attenuator to the front panel; three of these screws are immediately visible on removing the control knob as in (3) above; the two remaining screws are located immediately above and to the right of the coarse-attenuator panel markings.

With the attenuator detached as in (4) above, it remains coupled to the body of the instrument by two coaxial cables. These cables are, however, long enough to permit inspection and, if necessary, replacement of the attenuator-resistors without completely disconnecting the attenuator.

Reassemble the attenuator in the reverse order to that detailed above.

4.4.4 Mains Input Filter Unit

To gain access to the components comprising the mains input filter:

(1) Remove the nut and screw which secure, at the open end, the two halves of the mains filter unit screening cover.

(2) Separate the push-fit screening channel from the fixed half of the screening cover.

Reassemble the screening cover in the reverse order to that detailed above.

4.4.5 Power Unit

To remove the power unit from the instrument case:

(1) Remove, from the underside of the instrument case, the five screws which engage with nuts along the front and left-hand flanges of the power unit chassis.

(2) Holding the power unit with one hand, remove the remaining two screws which engage with the tapped bushes on the right-hand flange of the power unit.

Replace the power unit in the reverse order to that detailed above.

4.5 WORKING VOLTAGES

The voltages given in this section for guidance when servicing the instrument were obtained from measurements on a representative Signal Generator Type TF 995A/2; the voltmeter used had a resistance of 20,000 ohms per volt.

Mains Transformer, h.t. secondary:	250-0-250 V a.c.
Mains Transformer, l.t. (rectifier):	5 V a.c.
Mains Transformer, l.t. (main):	6.3 V a.c.
Positive H.T.:-	
Rectified (V11, pin 8):	300 V d.c.
Smoothed, HT1, (across C62):	230 V d.c.
Stabilized, HT3, (V9, pin 5):	150 V d.c.
Negative H.T. (junction of R117) and R118):	85 V d.c.

Valve electrode voltages are given in Table 4.

All voltages listed are with respect to chassis, and, except where alternative instructions are given, should be measured with the MOD SELECTOR switch set to INT MOD - A.M., the RANGE MC/S switch to 108-220, the SET CARRIER control to maximum, and the SET MOD control to minimum.

4.5 (continued)

TABLE 4

Valve No.	Va	Vg2	Vk
V1	250	50	1.3
V2	150	150	9
V3	150	75	-
V4	55	55	-
V5	250	250	7.5 40**
V6	83	120	-
V7(amp)*	250	-	2.3
V7(osc)*	250	-	-
V8	100	110	-
V10	120	120	-
V12	100	110	-

* When checking V7 voltages, set the RANGE MC/S switch to 1.5 - 13.5.

** The cathode potential of V5 increases to 40 volts when the MOD SELECTOR switch is set to INT MOD - F.M.

4.6 REPLACEMENT OF VALVES AND CRYSTALS

The types of valve used in the instrument, their base connections, and some guidance as to suitable alternatives if the types originally fitted are not readily available are given in the Valve Replacement Data Sheets.

The valves and crystals may normally be replaced without special selection. Valves V1, V5, V9, V11, and V13 to V15 are immediately accessible on removing the instrument from its case. To gain access to the 333.3-kc/s oscillator crystal, X1, and to the remaining valves, remove the R.F. Unit screening cover. The crystal rectifier, X2, forms part of the OUTPUT VOLTAGE attenuator assembly and can be removed by the procedure detailed in Section 4.4.3.

4.6 (continued)

Replacement of valves or crystals may necessitate either the reselection of associated components or readjustment of associated preset controls; aspects of this reselection and readjustment are discussed in Section 4.7 - Preset or Specially Selected Components.

4.7 PRESET OR SPECIALLY SELECTED COMPONENTS

In the manufacturing data for the TF 995A/2, certain of the components are either specified as being of the preset type or designated for individual selection, the setting or selection of the components being carried out during the factory calibration of the instrument; this is necessary since the operating characteristics of the instrument have to conform to a quantitative specification including maximum and minimum limits of permissible error.

The Description column of the Spares Ordering Schedule shows which of the components are of the preset type; components which are individually selected are distinguished in that column by a single asterisk mark.

If, in servicing a TF 995A/2, it is necessary to replace any of these components, it is also necessary, if the performance or accuracy of the instrument is not to be impaired, to repeat the factory calibration procedure by which the components were originally selected.

Section 4.8 gives a range of tests by which the main points of the performance of the instrument can be checked; this section also deals with the adjustment of preset components and with the choice of value for individually selected components.

It will be appreciated that it may sometimes be necessary to reselect a selected component even though that component itself has not been found faulty and replaced in initial servicing operations. To take an example - the internal modulation oscillator is tuned by T1 and C6. In manufacture, C6 is selected to give an oscillator frequency of 1,000 c/s ±5%. In servicing the instrument it might be found that T1 was faulty but that C6 was not. If T1 was replaced then it would be quite likely that with the original C6, the oscillator frequency would be outside the specified limits of ±5% and that a new value of capacitance would have to be chosen.

4.7 (continued)

It therefore follows that, in all servicing involving replacement of components, the user should consider carefully the possible effects on the performance of the stage or stages involved.

The table which follows lists the circuit reference numbers of both types of component together with the numbers of the sections in which their adjustment or selection is described.

TABLE 5

Component	Section Describing Adjustment or Selection	Component	Section Describing Adjustment or Selection
R2	4.8.12	R69	4.8.14
R5	4.8.10	R70	4.8.8
R6	4.8.10	R114	4.8.11
R7	4.8.10	R116	4.8.10
R8	4.8.10	R124	4.8.20
R9	4.8.10	C6	4.8.9
R11	4.8.10	C35	4.8.5
R12	4.8.10	C40	4.8.7
R13	4.8.10	C47	4.8.6
R14	4.8.10	C59	4.8.7
R19	4.8.11	C66	4.8.6
R24	4.8.13	C76	4.8.6
R39	4.8.18	C83	4.8.6
R50	4.8.11	T2	4.8.5
R63	4.8.17	T3	4.8.6
R65	4.8.14	L18	4.8.6
R66	4.8.14	L22	4.8.6
R67	4.8.14	L23	4.8.6
R68	4.8.14		

4.8 SCHEDULE OF TESTS

The following information, based on abstracts from the internal Factory Test Schedule, is included to enable the user to carry out a series of tests by which the main points of performance of the instrument can be checked; it also gives details concerning the adjustment to preset components and the choice of value for individually selected components.

4.8.1 Apparatus Required

(a) 750-volt Insulation Tester.

(b) Avo Meter, model 8.

(c) Wave Analyser; Marconi Type TF 455 (Series).

(d) Signal Generator, with standardized output; Marconi Types TF 801 (Series) or TF 995 (Series).

(e) Valve Voltmeter; Marconi Types TF 428 (Series), TF 958, TF 1041 (Series), TF 1100, or TF 1300.

(f) A.M. Communication Receiver, covering the range 1.5 to 220 Mc/s.

(g) Not required.

(h) 1-MΩ and $\frac{1}{2}$-MΩ resistors.

(i) Audio-Frequency Oscillator; Marconi Types TF 195 (Series), TF 885 (Series), TF 894 (Series), or TF 1101.

(j) Cathode-Ray Oscilloscope.

(k) Deviation Meter; Marconi Type TF 791 (Series).

N.B. For the F.M. on C.W. check (Section 4.8.20), where deviations of less than 50 c/s have to be measured, it is essential that the deviation meter should be modified to operate from battery supplies or, incorporate facilities allowing its local oscillator to be brought under crystal control.

4.8.2 Insulation (Apparatus required:- Item a)

Test the insulation between each pin of the supply plug and chassis with SK1 engaged with PL1. The reading should be not less than 40 MΩ.

4.8.3 Hum Level (Apparatus required:- Item c)

Measure the 100-c/s hum level using a wave analyser isolated from the TF 995A/2 by means of a suitable capacitor. The hum level should not exceed 20 mV as measured at the H.T.1 point.

4.8.4 Crystal Oscillator (Apparatus required:- Item e)

Plug head telephones into the CRYSTAL CHECK socket and turn the TUNE control until an audio beat is heard; adjust the core of L8 for maximum intensity of the audio beat note.

Measure the voltage across R27 with a valve voltmeter; it should be between 8 and 10 volts.

4.8.5 Basic Oscillator (Apparatus required:- Items e and f)

Set the MOD SELECTOR switch to C.W. and the main tuning dial to 27 Mc/s. Using a receiver as indicator, adjust C35 until the circuit oscillates at 9.0 Mc/s. Set the main tuning dial to 13.5 Mc/s, and adjust the core of T2 until the circuit oscillates at 4.5 Mc/s. Repeat these two adjustments.

Measure the r.f. voltages at the grid and anode of V3 using a valve voltmeter. These should be of the following orders:-

	4.5 Mc/s	9.0 Mc/s
Grid	2.2 volts	4.0 volts
Anode	22 volts	35 volts

Recheck the tuning adjustments against the crystal by means of high-resistance headphones plugged into the CRYSTAL CHECK socket. Fourteen check points should be heard. Check that the oscillator output is maintained when the dial is set to 27.5 Mc/s.

4.8.6 Frequency Multipliers (Apparatus required:- Items f and h)

(1) 13.5- to 27-Mc/s band

Set the MOD SELECTOR switch to C.W., the RANGE switch to 13.5 - 27 Mc/s, and the SET CARRIER control fully clockwise.

4.8.6 (continued)

Set the main dial to 13.5 Mc/s, and adjust the core of T3 for maximum deflection on the panel meter.

Set the main dial to 27 Mc/s, and adjust C47 for maximum deflection on the meter.

Use the receiver to check that, at these two points, the stage is operating at 13.5 and 27 Mc/s respectively, and that the Signal Generator tunes to 27.5 Mc/s at the appropriate dial reading.

(2) 27- to 54-Mc/s band

Set the RANGE switch to 27-54, and adjust C66 and the spacing of the turns of L18 at 54 and 27 Mc/s respectively for maximum deflection on the panel meter.

Use the receiver to check that, at these two points, the stage is operating at 54 and 27 Mc/s respectively, and that the Signal Generator tunes to 55 Mc/s at the appropriate dial reading.

(3) 54- to 108-Mc/s band

Set the RANGE switch to 54-108, and adjust C76 and the spacing of the turns on L22 at 108 and 54 Mc/s respectively.

Use the receiver to check that, at these two points, the stage is operating at 108 and 54 Mc/s respectively, and that the Signal Generator tunes to 110 Mc/s at the appropriate dial reading.

(4) 108- to 220-Mc/s band

Set the RANGE switch to 108-220, and adjust C83 and the spacing of the turns on L23 for maximum reading on the TF 995A/2 output meter at 216 and 108 Mc/s respectively.

Use the receiver to check that, at these two points, the stage is operating at 216 and 108 Mc/s respectively, and that the Signal Generator tunes to 220 Mc/s at the appropriate dial reading.

4.8.7 1.5- to 13.5-Mc/s Band (Apparatus required:- Item f)

This test must be made with the r.f. unit cover in position.

By means of a suitable jack plug, connect a pair of head telephones to the CRYSTAL CHECK socket.

Set the RANGE switch to 1.5 - 13.5, and adjust the TUNE control to bring the 30 Mc/s main dial marking (on the 27 - 54 Mc/s arc) to the cursor; then, using the crystal calibrator, tune for zero beat.

With the SET CARRIER control in its fully clockwise position adjust C40 and C59 alternately to give minimum deflection on the panel meter. These capacitors are accessible through two holes, slightly larger than the ventilation holes, in the top of the r.f. unit cover.

Connect the output of the Signal Generator to a receiver, and tune the receiver to some convenient accurately-known frequency between 1.5 and 13.5 Mc/s.

Set the main dial of the TF 995A/2 to this frequency, and adjust C40 for maximum receiver response.

In the absence of any other frequency standard, the receiver tuning may be standardized at frequencies between 4.5 and 9 Mc/s by loosely coupling its input to the basic oscillator of the TF 995A/2. This oscillator should first be standardized against the internal crystal calibrator, the basic-oscillator frequency being given by dividing by three the indication on the 13.5 - 27 scale.

4.8.8 R.F. Output Voltage Accuracy (Apparatus Required:- Items d, e, and f)

This test should be carried out with the instrument in its case.

Using a receiver as indicator, compare the output voltage with that of a standardized signal generator. If a constant error exists, it is probably due to a faulty monitor diode X2. This diode should have a backward resistance of 8 kΩ or greater when checked with a sensitive multi-range test meter, e.g., AvoMeter Model 8. If X2 is replaced, it will be necessary to select a new value for R70 in order to bring the output level within the limits of 0.89 to 1.12 of nominal up to 100 Mc/s, and 0.795 to 1.25 of nominal up to 220 Mc/s.

4.8.8 (continued)

Check at the following frequencies and levels: 25 Mc/s, 100 Mc/s, and 220 Mc/s; 100 mV and 10 μV.

4.8.9 Modulation Oscillator (Apparatus required:- Items e, i, and j)

Set the MOD SELECTOR switch to INT MOD - A.M., connect the output from the slider of the SET MOD potentiometer to the Y plates of a cathode-ray oscilloscope and the output of an a.f. oscillator to the X plates. Check the frequency of oscillation by the lissajous-figure method, and, if outside the limits of 950 to 1,050 c/s, select a new value for the tuning capacitor C6.

Measure the output voltage at the SYNC terminal with a valve voltmeter. It should not be less than 100 volts.

4.8.10 F.M. Deviation (Apparatus required:- Item k)

Set the DEVIATION - NORMAL/HIGH switch to NORMAL, the DEVIATION RANGE switch to 75 kc/s, the MOD SELECTOR switch to INT MOD - F.M., and the SET CARRIER control to give a convenient deflection on the TF 995A/2 output meter. Connect the output cable directly to a carrier deviation meter; set the TF 995A/2 attenuator controls to give maximum output; and tune both instruments to 13.5 Mc/s.

Depress the METER READS switch to F.M., and adjust the SET MOD control to give a meter indication of 75 kc/s deviation. By means of the carrier deviation meter, check that the deviation at 13.5 Mc/s is 75 kc/s ±5% and that this accuracy is maintained at 27.5 Mc/s. If the deviation is outside this accuracy, retune the Signal Generator and the deviation meter to 13.5 Mc/s, and select a value for R6 to give 75 kc/s deviation at this frequency.

Check that the deviation is within the limits stated at 27.5 Mc/s. If it is not, make slight adjustment to the angular position of the slider of R7 (relative to that of the tuning gang) to obtain equal deviations at 13.5 Mc/s and 27.5 Mc/s. Subsequent slight re-adjustment of R6 may then be necessary in order to maintain deviation accuracy.

4.8.10 (continued)

Check the deviation on the 27- to 54-Mc/s band to the same limits of accuracy as for the lower band. If it is outside these limits, measure the values of resistors R6, R115, and R116; let their sum be termed R_T.

Select values for R13 and R14, equal to R_T and $2R_T$ respectively, and make small adjustments to these values to obtain 75 kc/s deviation at 27 Mc/s. Check that this deviation is maintained at 55 Mc/s.

Check the deviation accuracy on the 54- to 108-Mc/s band. If it is outside the limits stated select a value for R11 equal to $3R_T$ and a value for R9 equal to $1.3R_T$ to bring the deviation at 54 and 110 Mc/s to the required accuracy.

Check the deviation accuracy on the 108- to 220-Mc/s band. If it is outside the limits stated, select a value for R5 equal to $7R_T$ and a value for R12 equal to $1.2R_T$ to bring the deviation at 108 and 220 Mc/s to the required accuracy.

If a deviation meter is not available, the following method may be used to determine the frequency deviation. This method - the disappearing carrier method - depends upon the fact that the carrier, as opposed, of course, to the sidebands, disappears when the modulation index μ (the ratio of the frequency deviation δF to the modulation frequency f) has values of 2.4, 5.52, 8.65, 11.79, etc. Therefore, if the modulation frequency, f, is known, since deviation, δF, is equal to μf, deviation can be simply calculated when μ is known - i.e., at a carrier disappearance point. For example, if the applied modulation has a frequency of 10 kc/s and the deviation is progressively increased until the carrier disappears, the deviation must be $2.4 \times 10 = 24$ kc/s, and again $5.52 \times 10 = 55.2$ kc/s.

A deviation check at 75 kc/s can be obtained at the second disappearance with a modulation frequency of 13.6 kc/s.

To determine these points, apply the output of the TF 995A/2 to a narrow-band (communication) a.m. receiver and tune the latter to the unmodulated output frequency of the TF 995A/2. Set the beat oscillator of the receiver to give an audio note; then frequency modulate the Signal Generator at a fairly high frequency outside the passband of the a.m. receiver - such as 10 kc/s - starting from zero deviation and increasing the deviation until the beat with the carrier disappears. At this point, the actual deviation can be calculated as described above.

4.8.11 Incremental Frequency (Apparatus required:- Items i and j)

Check the calibration of the INC FREQ dial in the following manner:-

(1) By means of a suitable jack plug, connect a pair of head telephones to the CRYSTAL CHECK socket; set the MOD SELECTOR switch to C.W.; then set the INC FREQ control to its centre-zero position and short-circuit the slider of its potentiometer, R112, to chassis.

(2) Adjust the TUNE control to bring the frequency of the r.f. oscillator to some convenient crystal check point near the low-frequency end of the range, and tune carefully to zero beat.

(3) Disconnect the short-circuit between the slider of R112 and chassis, and check that zero-beat occurs when the INC FREQ control is within 2 kc/s of its centre zero position.

(4) If zero beat does not occur with the control within 2 kc/s of its zero setting, check that the dial is positioned on its spindle so that the 0 coincides with the cursor when the potentiometer is at its mid-travel position; then select a value for R50 to bring the frequency to zero beat with the INC FREQ dial reading zero.

(5) Having obtained satisfactory operation at zero frequency-shift position, disconnect the telephones and connect in their place the Y input of a cathode-ray oscilloscope. Connect an a.f. oscillator to the X input of the oscilloscope, and adjust the frequency of this oscillator to exactly 3.33 kc/s.

(6) Using the lissajous-figure method, check the accuracy of the incremental dial at each calibration point. A calibrated movement of 10 kc/s on the incremental dial corresponds to an actual shift of the r.f. oscillator frequency of 3.33 kc/s.

(7) If necessary, select a value for R114 to bring the calibration of the INC FREQ dial to an accuracy of 10%.

4.8.12 F.M. Distortion (Apparatus required:- Items c and k)

Set the DEVIATION NORMAL/HIGH switch to NORMAL, the DEVIATION RANGE switch to 75 kc/s, the MOD SELECTOR switch to INT MOD - F.M., and the RANGE switch to 13.5 - 27; then adjust the SET CARRIER control to give a convenient deflection on the TF 995A/2 panel meter.

Connect the output cable directly to a carrier deviation meter, tune both instruments to 20 Mc/s, and adjust the TF 995A/2 attenuators for maximum output.

Adjust the SET MOD control to produce 75 kc/s deviation, and check that the positive and negative deviations as indicated on the deviation meter are equal. If they are unequal, select a value for R19 to produce equal positive and negative deviations.

Apply the demodulated f.m. signal from the deviation meter to a wave analyser, and measure the total distortion at carrier frequencies of 13.5, 27, 90, and 220 Mc/s. The total f.m. distortion should not exceed 2%.

4.8.13 Deviation Range Adjustments (Apparatus required: Item k)

Set the DEVIATION - NORMAL/HIGH switch to NORMAL, the DEVIATION RANGE switch to 75 kc/s, the MOD SEIECTOR switch to INT MOD - F.M., and adjust the SET CARRIER control to bring the meter pointer to SET R.F. Set the OUTPUT VOLTAGE and MULTIPLY BY attenuators to 100 dB, connect the output cable directly to a deviation meter, and tune both instruments to the same frequency.

Adjust the SET MOD control to maximum and select a value for R2 which will produce a deviation of approximately 85 kc/s, as measured on the deviation meter.

Set the DEVIATION RANGE switch to 25 kc/s and select a value for R24 so that a deviation of approximately 28 kc/s is obtained with the SET MOD control at its maximum position.

4.8.14 Deviation Monitor Circuit (Apparatus required:- Item k)

Check the accuracy of the deviation reading on the TF 995A/2 meter using a deviation meter or the disappearing carrier method described in section 4.8.10. If the indication of the TF 995A/2 is not accurate, adjust R65. If adjustment of R65 does not correct the error on both ranges, proceed as follows.

Turn the SET MOD control to zero and the preset control R65 to mid-travel; set the DEVIATION RANGE switch to 25 kc/s and hold the METER READS switch to F.M. Select R69 to give zero reading on the TF 995A/2 meter.

Set the METER READS switch to C.W. and rotate the SET MOD control until 25 kc/s deviation is indicated on the deviation meter. Hold the METER READS switch to F.M. and select R67 so that the TF 995A/2 meter indicates the 25 kc/s deviation.

Set the DEVIATION RANGE switch to 75 kc/s, rotate the SET MOD control to zero, and hold the METER READS switch to F.M. Select R68 to give zero reading on the TF 995A/2 meter. Return the METER READS switch to C.W., and rotate the SET MOD control until 75 kc/s deviation is indicated on the deviation meter. Hold the METER READS switch to F.M. and select R66 to give full scale reading on the TF 995A/2 meter.

Finally, re-check the deviation calibration at several points on each band.

4.8.15 High Deviation (Apparatus required:- Item k)

Connect the output of the TF 995A/2 to a deviation meter and check that, when the TF 995A/2 is set for 9 kc/s deviation with the DEVIATION - NORMAL/HIGH switch set to NORMAL, the deviation, indicated on the deviation meter, rises to approximately the following values when the DEVIATION - NORMAL/HIGH switch is set to HIGH.

4.8.15 (continued)

RANGE Mc/s	HIGH Deviation for 9 kc/s NORMAL
1.5-13.5	18 kc/s
13.5-27	9 kc/s
27-54	18 kc/s
54-108	36 kc/s
108-220	72 kc/s

4.8.16 External F.M. (Apparatus required:- Items i and k)

Connect the output of a beat frequency oscillator to the EXT MOD and E terminals and set it to deliver 30 volts r.m.s. at 1 kc/s. Set the MOD SELECTOR switch to EXT MOD - F.M., the DEVIATION - NORMAL/HIGH switch to NORMAL, hold the METER READS switch to F.M., and adjust the SET MOD control for 75 kc/s deviation. Tune the beat frequency oscillator over the range 50 c/s to 15 kc/s and check that the input required for 75 kc/s deviation does not vary by much more than ±1 dB.

Feed the output of the TF 995A/2 to the deviation meter and repeat the operation using the deviation meter as indicator; check that not more than ±1 dB variation in input is required to maintain the deviation at 75 kc/s.

4.8.17 Internal A.M. (Apparatus required:-- Items c, f, and j)

Apply the output of the TF 995A/2 to a frequency changer circuit which is followed by an i.f. amplifier and cathode ray oscilloscope; the i.f. amplifier should have a centre frequency which will allow its output to be viewed directly on the c.r.o. Set the MOD SELECTOR switch to INT MOD - A.M. and adjust the SET MOD control for 30% modulation as measured on the c.r.o. screen using the formula:-

4.8.17 (continued)

$$M(\%) = \frac{D\ max - D\ min}{D\ max + D\ min} \times 100$$

where D max = the peak-to-peak dimensions of the c.r.o. display.

D min = the trough-to-trough dimensions of the c.r.o. display.

Hold the METER READS switch to A.M. and check that the meter reading is correct. If not, select a new value for R63.

Using the wave analyser check that the total distortion of the detected output appearing across R70 does not, in general, exceed 5% at 30% modulation.

4.8.18 External A.M. (Apparatus required:- Items f, i, and j)

Connect the output of a beat frequency oscillator to the EXT MOD and E terminals, and adjust it to produce approximately 30 volts r.m.s. Set the MOD SELECTOR switch to EXT MOD - A.M. and adjust the SET CARRIER control so that the meter reads SET R.F. Adjust the SET MOD control to produce 30% modulation depth at 1.000 c/s, as measured on an oscilloscope in the manner outlined in Section 4.8.17. Tune the beat frequency oscillator from 50 c/s to 10 kc/s and check that the input required to produce 30% modulation is flat within 1 dB relative to 1,000 c/s. If not, select a value for R39 which fulfils these conditions.

4.8.19 Spurious A.M. (Apparatus required:- Item a)

Set the TF 995A/2 for 10% a.m. at 20 Mc/s and measure the a.c. voltage appearing across R70. Set to 75 kc/s deviation and check that the voltage across R70 is not greater than before.

4.8.20 Spurious F.M. on C.W. (Apparatus required:- Items c and k)

When making this check, the instrument should be removed from its case but should be bonded to the power unit by a length of copper braid or heavy-gauge wire.

4.8.20 (continued)

(1) Connect the generator output to the deviation meter. Note that since the deviation to be measured is as low as 50 c/s, it is essential that the deviation meter itself generates negligible spurious f.m. This can be achieved either by modifying the deviation meter to operate from batteries or by using a deviation meter whose local oscillation can be brought under crystal control.

(2) In order to detect the small amount of deviation accurately, connect the Wave Analyser to the "L.F. Output" terminals of the deviation meter.

(3) Set up the Signal Generator for, say, 10 kc/s internal f.m. deviation at a carrier frequency of 10 Mc/s.

(4) Peak the wave analyser reading by tuning the deviation meter in the normal manner for a 10 Mc/s input and by tuning the Wave Analyser to the modulating frequency. From this reading, the Wave Analyser can be calibrated in terms of mV per kc/s deviation.

(5) Set the modulation selector to C.W. and, with the Carrier Deviation Meter still tuned to the 10 Mc/s carrier frequency, tune the Wave Analyser to the frequency of the power supply.

(6) Adjust R124 until the Wave Analyser indication is at a minimum. This resistor is accessible through a small hole in the side of the r.f. unit cover.

(7) Measure the levels of the hum and ripple components and, from the geometric sum, calculate the deviation. The deviation should be less than 50 c/s.

(8) Repeat operations (5), (6), and (7) for a selection of frequencies up to 220 Mc/s. Below 100 Mc/s, the spurious deviation should be less than 50 c/s; between 100 and 220 Mc/s, the deviation should be less than 100 c/s.

AMENDMENT NO. AM4

TO

OPERATING AND MAINTENANCE HANDBOOK NO. OM 995A/2

1. A two-pole toggle switch, S7, designated CARRIER ON/OFF has been added. It is situated at the right-hand side of the front panel between the SET MOD control and the MULTIPLY BY attenuator. On Circuit Diagram TLD 23080/2, one pole is interposed between the anode, pin 5, of voltage stabilizer V9 and the junction of C12 and L4, i.e., in the HT3 line; the other pole is interposed between the slider of the SET CARRIER potentiometer, R44, and the junction of C57 and R47, i.e., in the screen supply to the harmonic multipliers.

2. A low-pass π-section filter has been added to improve the suppression of unwanted components in the output when the Signal Generator is set to the 1.5 to 13.5 Mc/s band. The filter consists of an inductor, L26, and two capacitors, C94 and C95. These components are situated to the right of the screening plate mounted over V12 valve base; V12 is shown on MP 995A/2-5. On Circuit Diagram No. TLD 23080/2, L26 is connected in series with the lead joining the high end of T5 secondary and tag 7 of switch S2g. C94 is connected between earth and the junction of L26 and T5; C95 is connected between earth and the other side of L26.

3. A variable resistor, R124, and a fixed resistor, R123, have been added so that any spurious f.m. on c.w. due to power-supply hum can be adjusted to a minimum. They are situated at the end of the r.f. unit chassis adjacent to valve V2, and are mounted on a bracket attached to the side of the chassis; this chassis shown on MP 995A/2-4.

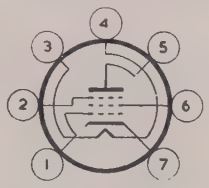
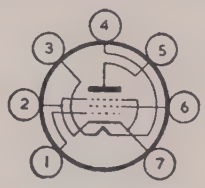
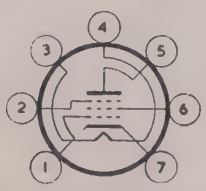
4. A capacitor, C96 has been added in parallel with L15 which is itself in series with pin 7 of V7.

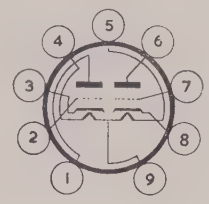
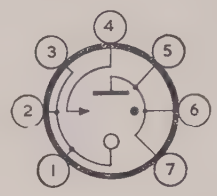
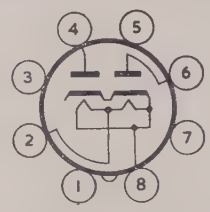
VALVE REPLACEMENT DATA

FOR

F.M./A.M. SIGNAL GENERATOR Type TF 995A/2

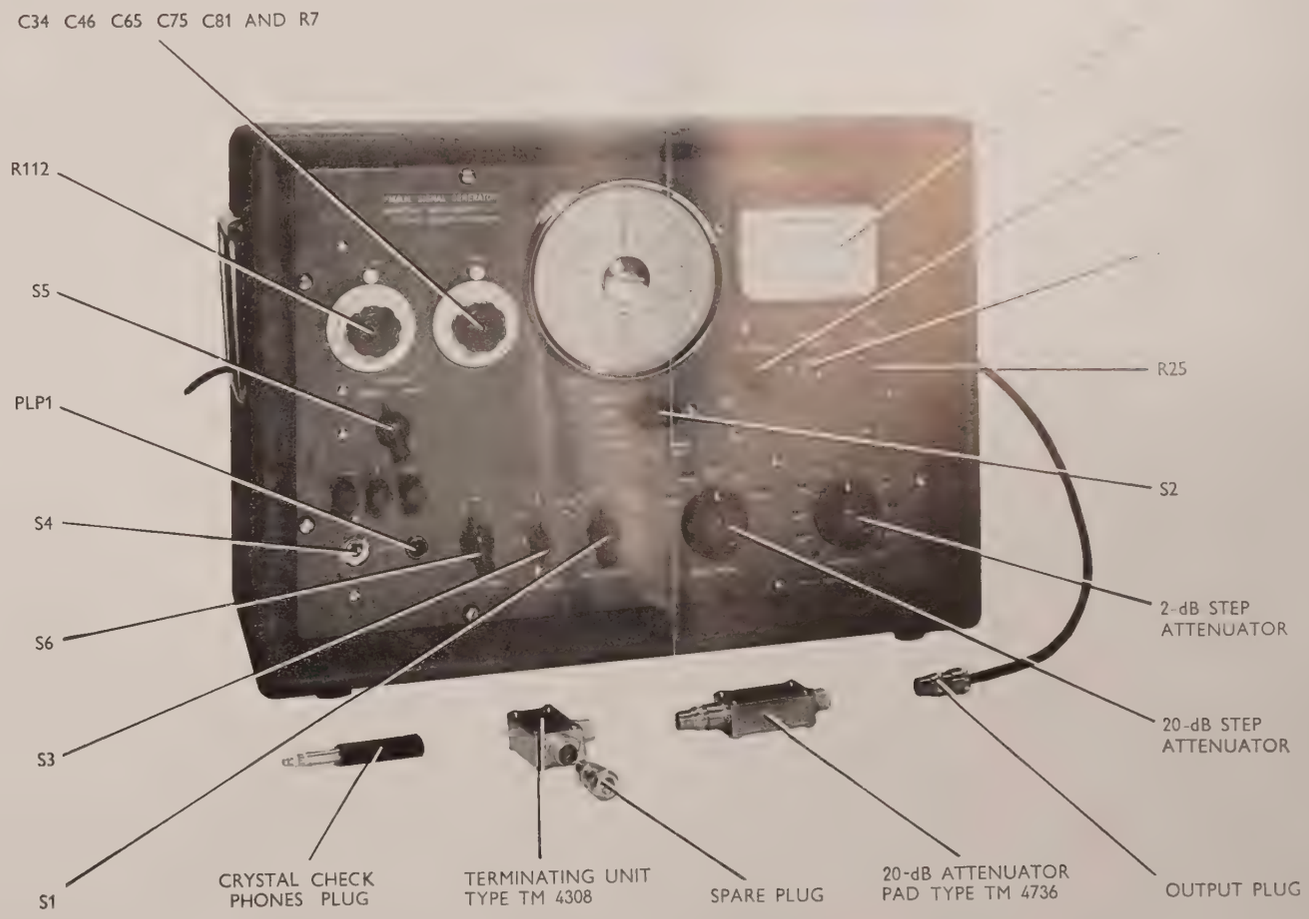
Any valve which becomes faulty should preferably be replaced by a valve of the type originally supplied in the instrument and designated in the following table. If this is not possible, the additional data given by the table may be used as a guide to suitable alternatives.

Valve	*British Commercial Equivalent*	*British Services Equivalent*	*Base*	*U.S. Equivalent*
V1, V2 POWER PENTODE BRIMAR 6AK6		CV1762	MINIATURE 7-PIN (B7G) 	6AK6
V3, V4, V6, V8, V10, V12 H.F. PENTODE MULLARD EF95	6AK5	CV850	MINIATURE 7-PIN (B7G) 	6AK5
V5 PENTODE BRIMAR 6AU6		CV2524 CV4023	MINIATURE 7-PIN (B7G) 	6AU6

Valve	British Commercial Equivalent	British Services Equivalent	Base	U.S. Equivalent
V7 DOUBLE TRIODE BRIMAR 12AT7	ECC81	CV455	MINIATURE 9-PIN (B9A) 	12AT7
V9 VOLTAGE STABILIZER MARCONI QS150/15	QS1200* OA2*	CV287 CV1832* CV4020*	MINIATURE 7-PIN (B7G) 	OA2*
V11 FULL-WAVE RECTIFIER BRIMAR 5Z4G	R52 GZ30 52KU U50	CV1863	INTERNATIONAL OCTAL 	5Z4G
V13, V15 DOUBLE DIODE MARCONI D77	6AL5 6D2 D152 DD6 EB91	CV140	MINIATURE 7-PIN (B7G) 	6AL5
V14 VOLTAGE STABILIZER MULLARD 85A2	QS1209 QS83/3	CV449	MINIATURE 7-PIN (B7G) 	5651

*The base connections for these voltage stabilizers are different from those of the type QS150/15 (CV287). The holder for V9 in the TF 995A/2 has been specially wired so that, without rewiring, any of the voltage stabilizers listed on this sheet can be used.

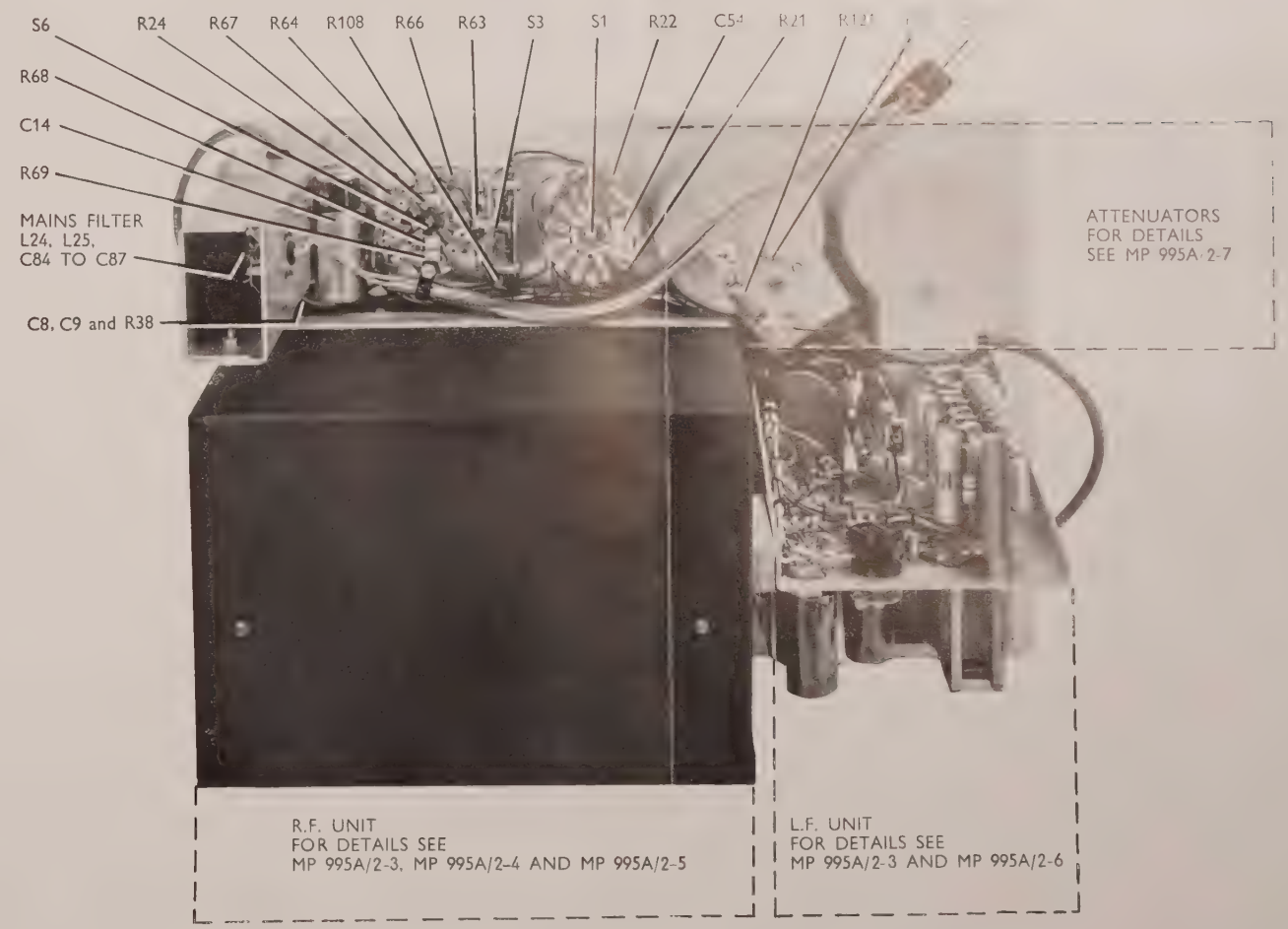
FRONT PANEL



FRONT PANEL

MARCONI INSTRUMENTS LIMITED							
DRN	D.H.	DATE	6.7.56	CHKD	J.F.G.	ISSUE	2
STOCK LIST	TF 995A/2			DRG No.	MP 995A/2-▌		

GENERAL
UNDERSIDE VIEW
FROM REAR
(CASE REMOVED)



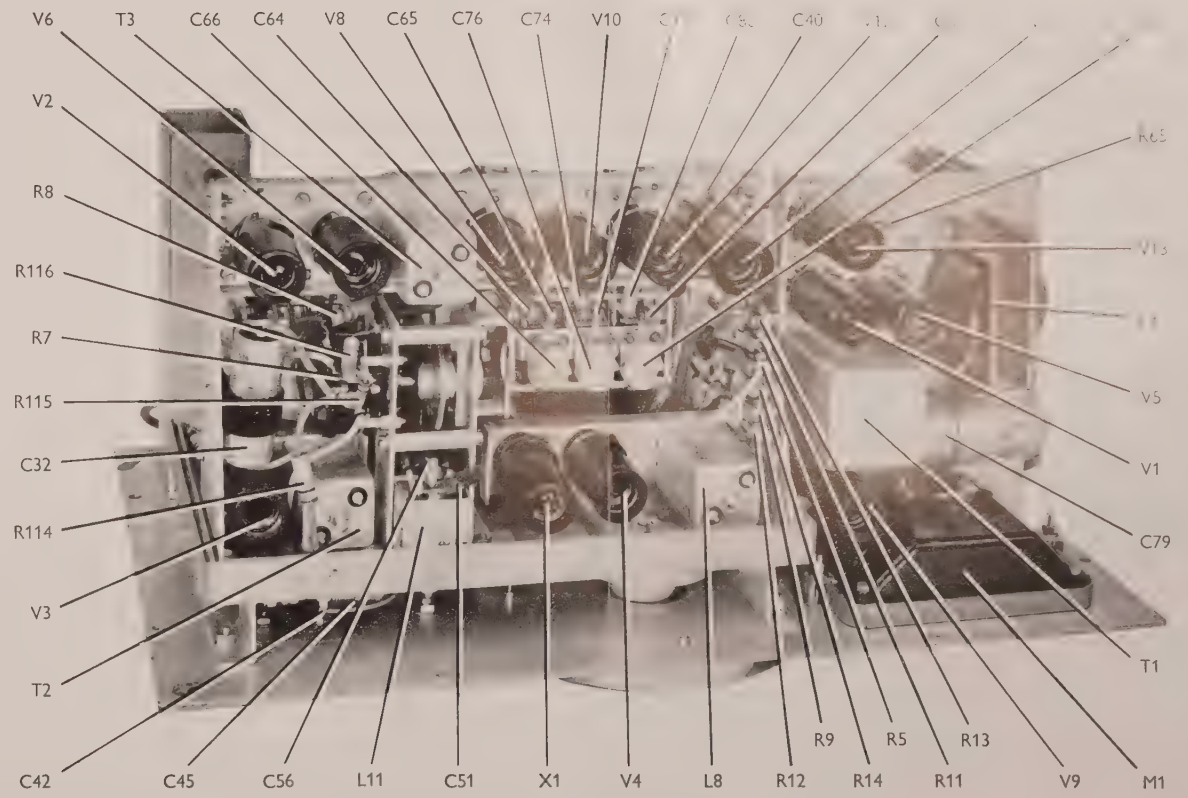
GENERAL UNDERSIDE VIEW FROM REAR (CASE REMOVED)

MARCONI INSTRUMENTS LIMITED							
DRN	D.H.	DATE	6.7.56	CHKD	J.F.G.	ISSUE	2
STOCK LIST	TF 995A/2			DRG No.	MP 995A/2-**2**		

L.F. AND R.F. UNITS

(TOP VIEW WITH R.F. UNIT SCREENING COVER REMOVED)

MARCONI INSTRUMENTS LIMITED							
DRN	D.H.	DATE	6.7.56	CHKD	J.F.G.	ISSUE	2
STOCK LIST	TF 995A/2			DRG No.	MP 995A/2-**3**		



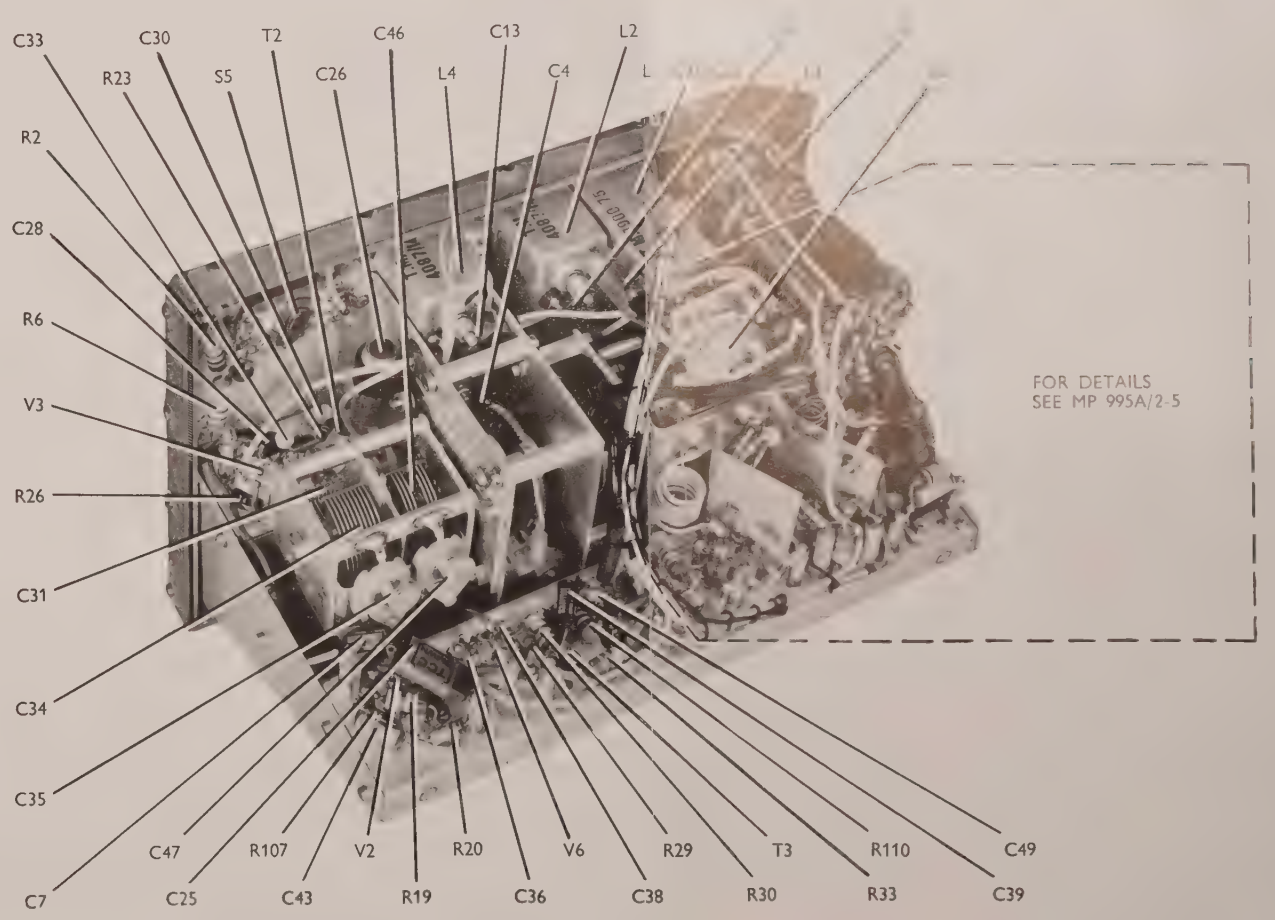
L.F. AND R.F. UNITS (TOP VIEW WITH R.F. UNIT SCREENING COVER REMOVED)

C P 2c 111 59

R.F. UNIT

(GENERAL UNDERSIDE VIEW)

MARCONI INSTRUMENTS LIMITED							
DRN	D.H.	DATE	6.7.56	CHKD	J.F.G.	ISSUE	2
STOCK LIST	TF 995A/2			DRG No.	MP 995A/2-**4**		

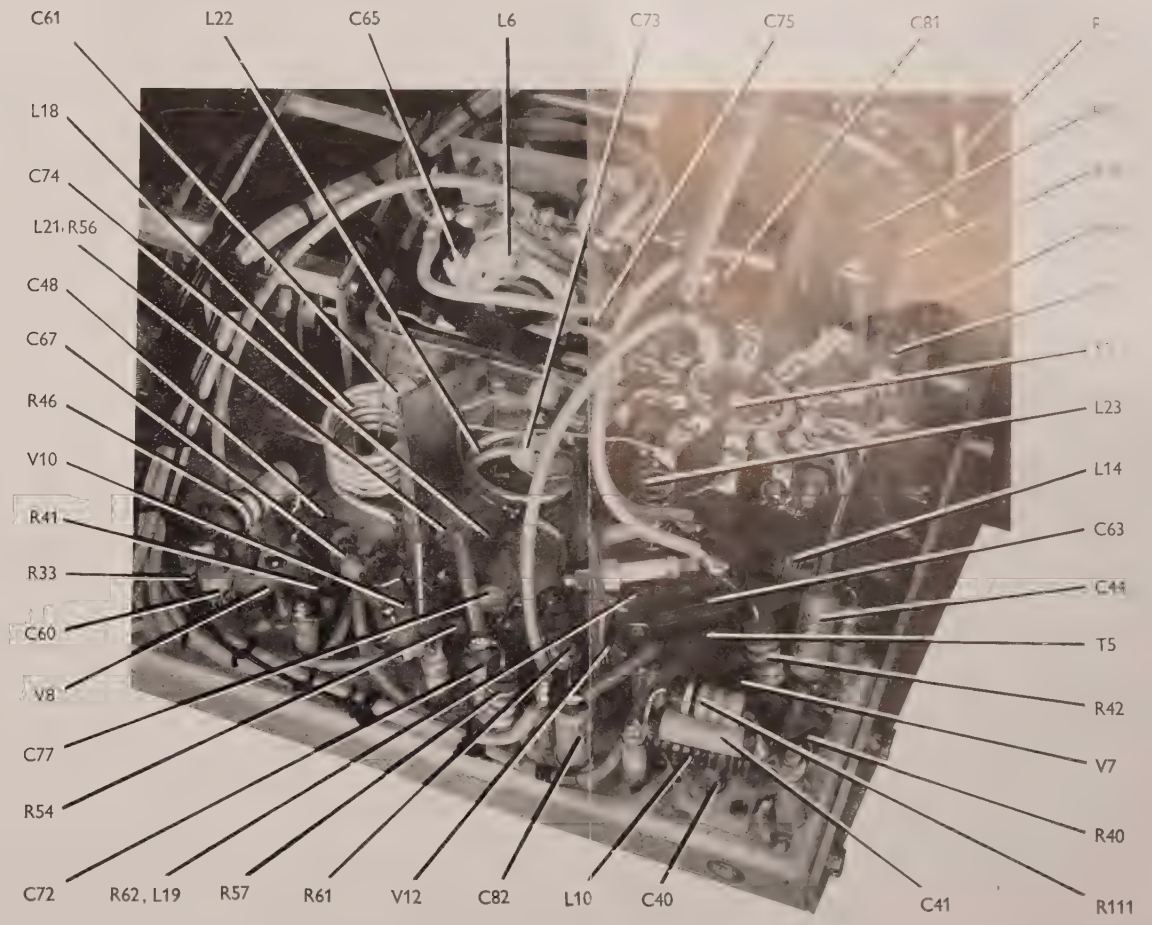


R.F. UNIT (GENERAL UNDERSIDE VIEW)

C.P. 2c 10 59

R.F. UNIT

(CLOSE UP OF PORTION OF UNDERSIDE)



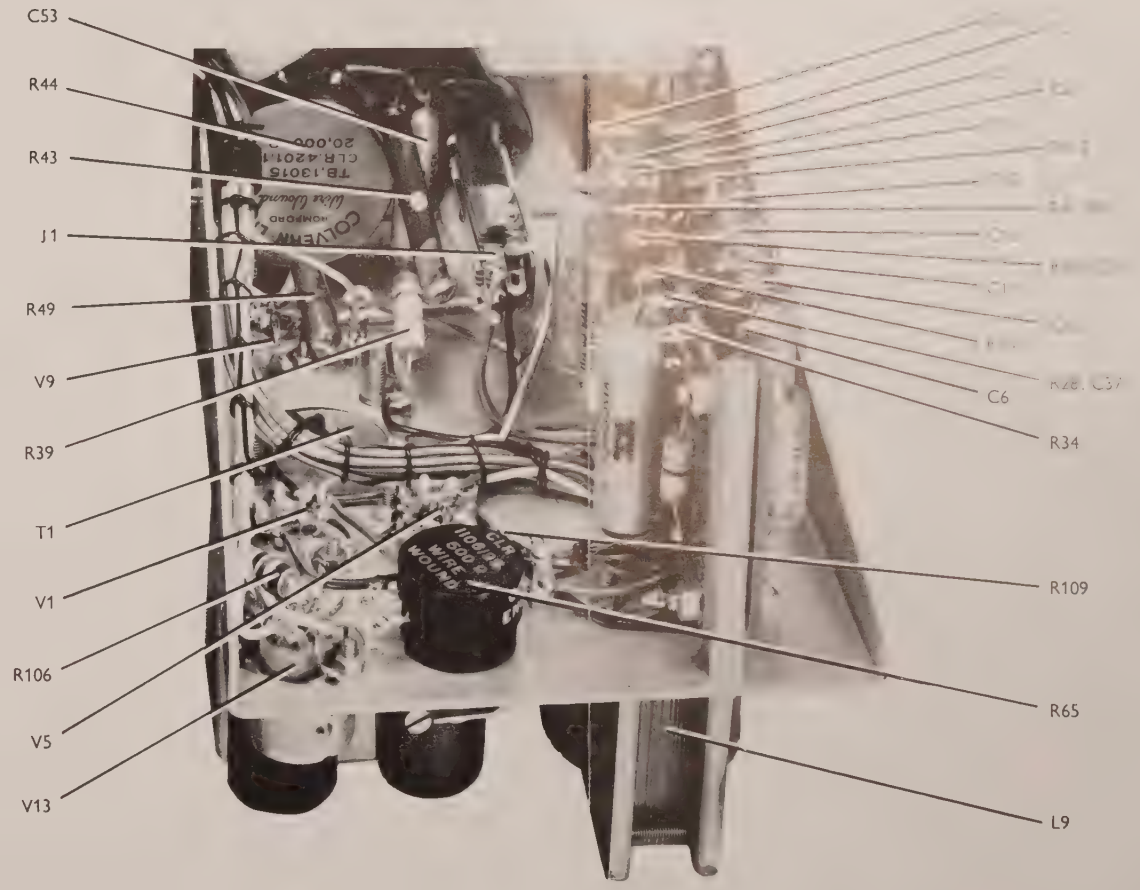
R.F. UNIT (CLOSE UP OF PORTION OF UNDERSIDE)

MARCONI INSTRUMENTS LIMITED							
DRN	D.H.	DATE	6.7.56	CHKD	J.F.G.	ISSUE	2
STOCK LIST	TF 995A/2			DRG No.	MP 995A/2-**5**		

C.P. 2c 10 59

L.F. UNIT

(UNDERSIDE VIEW)



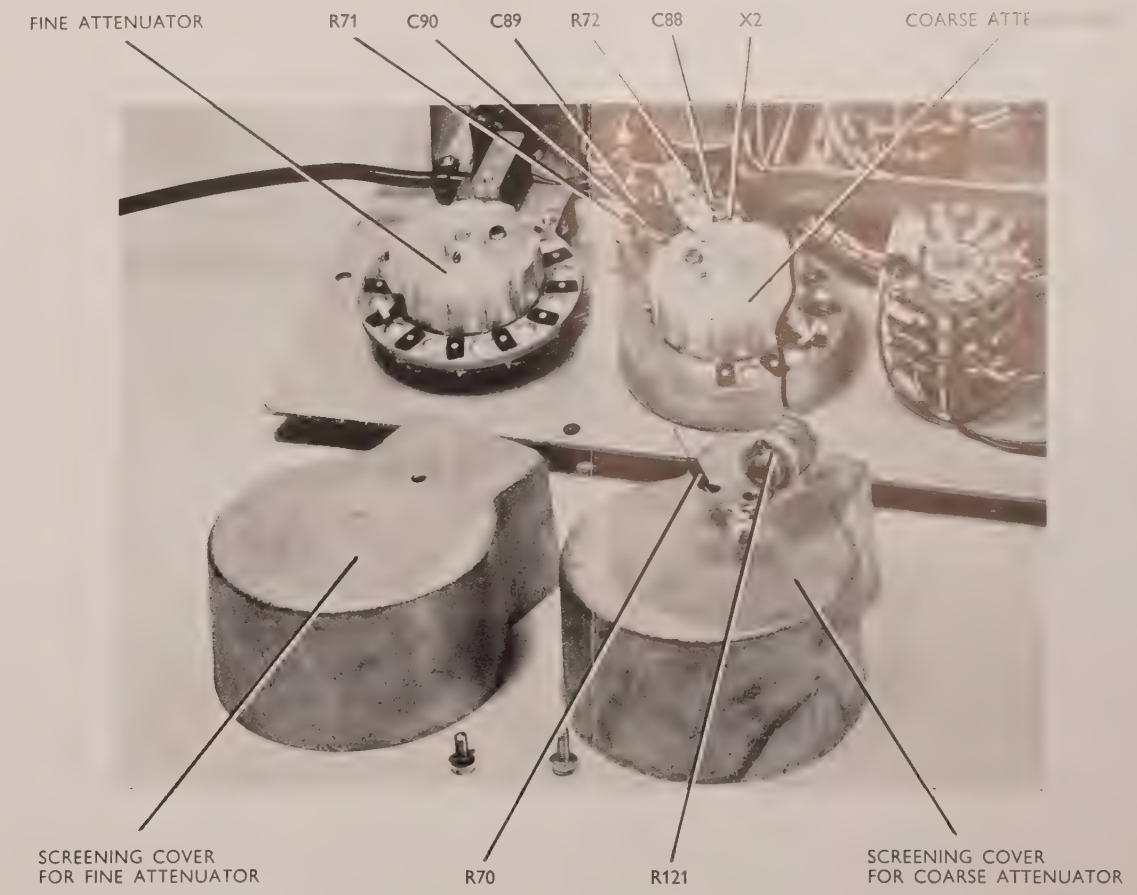
L.F. UNIT (UNDERSIDE VIEW)

MARCONI INSTRUMENTS LIMITED							
DRN	D.H.	DATE	6.7.56	CHKD	J.F.G.	ISSUE	2
STOCK LIST	TF 995A/2		DRG No.	MP 995A/2-**6**			

C.P. 2c 10 59

ATTENUATORS
(COVERS REMOVED)

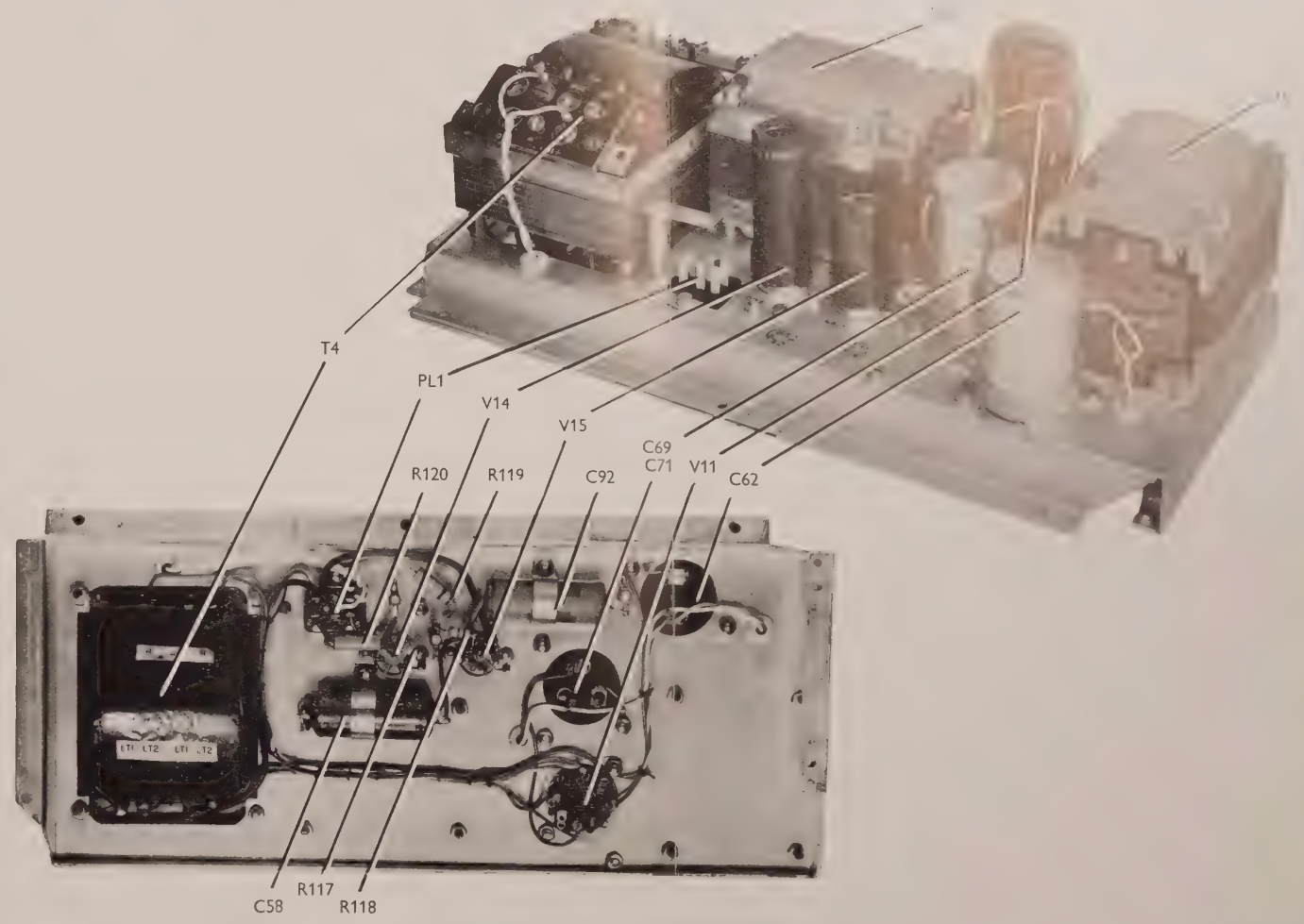
MARCONI INSTRUMENTS LIMITED							
DRN	D.H.	DATE	6.7.56	CHKD	J.F.G.	ISSUE	2
STOCK LIST	TF 995A/2			DRG No.	MP 995A/2–7		



ATTENUATORS (COVERS REMOVED)

C.P. 2c 10.59

POWER UNIT



NOTE:
On current models an additional resistor, R122, is connected in parallel with capacitor C58.

POWER UNIT

MARCONI INSTRUMENTS LIMITED							
DRN	D.H.	DATE	2/57	CHKD	J.F.G.	ISSUE	3
STOCK LIST	TF 995A/2			DRG No.	MP 995A/2-**8**		

SPARES ORDERING SCHEDULE NO. SOS/995A/2

WITH CIRCUIT REFERENCES

for

F.M./A.M. SIGNAL GENERATOR TYPE TF 995A/2

Applicable to Instruments
Serial Nos:-

5036001 to 5036500
5123001 to 5123500
5284001 to 5284200
5346001 to 5346200
JA103/001 to JA103/300

When ordering replacement parts, ALWAYS QUOTE THE TYPE NUMBER AND SERIAL NUMBER OF THE INSTRUMENT CONCERNED.

To specify the individual parts required, STATE FOR EACH PART THE QUANTITY REQUIRED AND THE APPROPRIATE SOS ITEM NUMBER.

For example, to order replacements for the 220-kΩ resistor, R4, and the 5-μμF capacitor, C73, order as follows:-

Spares required for TF 995A/2, Serial Number 000000

1 off, SOS Item 4
1 off, SOS Item 186

It is important that the code "SOS" preceding each item number is not omitted.

SOS Item No.	Circuit Ref.	Description	Works Ref.
		RESISTORS	
1	R1	Composition, 470 kΩ ±20%, 1/4 W.	4-TM4800/2
2	R2	Composition, 1.5 kΩ*, ½ W.	PC66611/27
3	R3	Composition, 220 kΩ ±10%, ½ W.	PC66611/53
4	R4	Composition, 220 kΩ ±10%, 1/4 W.	PC66609/48
5	R5	Composition, 27 kΩ*, 1/4 W.	PC66609/36
6a	R6	Composition, 2.2 kΩ*, ½ W.	PC66611/29
7	R7	Wire-Wound, 50 kΩ Variable ±10%, 3 W.	18-TM4831/2
8	R8	Composition, 47 kΩ*, ±10%, 1/4 W.	PC66609/33
9	R9	Composition, 5.1 kΩ*, ½ W.	7-TM4706/2
10	R10	Composition, 10 kΩ ±10%, ½ W.	PC66611/37
11	R11	Composition, 12 kΩ*, 1/4 W.	PC66609/32
12	R12	Composition, 4.7 kΩ*, ½ W.	PC66611/33
13	R13	Composition, 3.9 kΩ*, 1/4 W.	PC66609/26
14	R14	Composition, 8.2 kΩ*, ½ W.	PC66611/36
15	R15	Composition, 4.7 kΩ ±10%, 1/4 W.	PC66609/27
16	R16	Wire-Wound, 4.7 kΩ ±5%, 7 W.	113-TM4826/2
17	R18	Composition, 220 kΩ ±10%, 1/4 W.	PC66609/47
18	R19	Composition, 1.2 kΩ*, 1/4 W.	PC66609/20
19	R20	Composition, 10 kΩ ±5%, 1/4 W.	62-TM4826/2
20	R21	Composition, 68 kΩ ±10%, 1/4 W.	PC66609/41

* Nominal value; actual value determined during calibration

SOS Item No.	Circuit Ref.	Description	Works Ref.
		RESISTORS(continued)	
21	R22	Composition, 68 kΩ ±10%, 1/4 W.	PC66609/41
22	R23	Composition, 56 kΩ ±10%, 1/4 W.	PC66609/40
23	R24	Composition, 39 kΩ*, 1/4 W.	PC66609/38
24	R25	Composition, 20 kΩ Variable ±20%, 1/4 W.	74-TF995A/2
25	R26	Composition, 15 kΩ ±10%, 1/4 W.	PC66609/33
26	R27	Composition, 2.7 MΩ ±10%, 1/4 W.	PC66609/60
27	R28	Composition, 220 kΩ ±10%, 1/4 W.	PC66609/47
28	R29	Composition, 6.8 kΩ ±10%, 1/4 W.	PC66609/29
29	R30	Composition, 6.8 kΩ ±10%, 1/4 W.	PC66609/29
30	R31	Composition, 270 kΩ ±10%, 1/4 W.	PC66609/48
31	R32	Composition, 100 Ω ±10%, 1/4 W.	PC66609/7
32	R33	Composition, 2.2 kΩ ±10%, 1/4 W.	PC66609/23
33	R34	Composition, 390 Ω ±5%, 1/4 W.	11-TM4800/2
34	R35	Wire-Wound, 15 kΩ ±5%, 7 W.	112-TM4826/2
35	R36	Wire-Wound, 7.5 kΩ ±5%, 7 W.	111-TM4826/2
36	R37	Wire-Wound, 5 kΩ ±5%, 7 W.	110-TM4826/2
37	R38	Composition, 10 Ω ±10%, $\frac{1}{2}$ W.	PC66611/1
38	R39	Composition, 220 kΩ*, $\frac{1}{2}$ W.	PC66611/53
39	R40	Composition, 15 kΩ ±10%, 1/4 W.	PC66609/33

* Nominal value; actual value determined during calibration

SOS Item No.	Circuit Ref.	Description	Works Ref.
		RESISTORS (continued)	
40	R41	Composition, 6.8 kΩ ±10%, 1/4 W.	PC66609/29
41	R42	Composition, 2.2 kΩ ±10%, 1/4 W.	PC66609/23
42	R43	Composition, 10 kΩ ±10%, 1 W.	PC66621/37
43	R44	Wire-Wound, 20 kΩ Variable, ±10%, 3 W.	75-TF995A/2
44	R45	Composition, 100 kΩ ±10%, 1/4 W.	PC66609/43
45	R46	Composition, 6.8 kΩ ±10%, ½ W.	PC66611/35
46	R47	Composition, 10 kΩ ±10%, ½ W.	PC66611/37
47	R48	Composition, 2.2 kΩ ±10%, 1/4 W.	PC66609/23
48	R49	Wire-Wound, 4 kΩ ±5%, 7 W.	72-TF995A/2
49	R50	Composition, 100 kΩ*, ½ W.	PC66611/49
50	R51	Composition, 4.7 kΩ ±10%, 1/4 W.	PC66609/27
51	R52	Composition, 220 kΩ ±10%, 1/4 W.	PC66609/44
52	R53	Composition, 270 Ω ±10%, 1/4 W.	PC66609/12
53	R54	Composition, 6.8 kΩ ±10%, 1/4 W.	PC66609/29
54	R55	Composition, 68 kΩ ±10%, 1/4 W.	PC66609/41
55	R56	Composition, 47 kΩ ±20%, ½ W; includes L21.	TB23173/9
56	R57	Composition, 2.2 kΩ ±10%, 1/4 W.	PC66609/23
57	R58	Composition, 100 kΩ ±10%, 1/4 W.	PC66609/43
58	R59	Composition, 6.8 kΩ ±10%, 1/4 W.	PC66609/29
59	R60	Composition, 100 kΩ ±10%, 1/4 W.	PC66609/43

SOS Item No.	Circuit Ref.	Description	Works Ref.
		RESISTORS (continued)	
60	R61	Composition, 2.2 kΩ ±10%, 1/4 W.	PC66609/23
61	R62	Composition, 33 kΩ ±20%, ½ W; includes L19.	TB23173/10
62	R63	Composition, 750 kΩ* 1/4 W.	78-TF995A/2
63	R64	Composition, 470 Ω ±10%, 1/4 W.	PC66609/15
64	R65	Wire-Wound, 500 Ω Variable, ±20%, 1/4 W.	PC67401/17
65	R66	Composition, 180 kΩ*, ½ W.	PC66609/46
66	R67	Composition, 56 kΩ*, ½ W.	PC66609/40
67	R68	Composition, 150 kΩ*, 1/4 W.	PC66609/45
68	R69	Composition, 47 kΩ*, 1/4 W.	PC66609/39
69a	R70	Composition, 3.3 kΩ*, 1/4 W.	PC66609/24
70	R71	Composition, 1 kΩ ±20%, 1/8 W.	39-TM4297A
71	R72	Composition, 1 kΩ ±20%, 1/8 W.	39-TM4297A
72	R73	Carbon, High Stability, 82.5 kΩ ±1%, 1/8 W.	36-TM4297A
73	R74	Carbon, High Stability, 742 Ω ±1%, 1/8 W.	35-TM4297A
74	R75	Carbon, High Stability, 742 Ω ±1%, 1/8 W.	35-TM4297A
75	R76	Carbon, High Stability, 742 Ω ±1%, 1/8 W.	35-TM4297A
76	R77	Carbon, High Stability, 742 Ω ±1%, 1/8 W.	35-TM4297A
77	R78	Carbon, High Stability, 220 Ω ±1%, 1/8 W.	38-TM4297A
78	R79	Carbon, High Stability, 91.6 Ω ±1%, 1/8 W.	37-TM4297A

* Nominal value; actual value determined during calibration

SOS Item No.	Circuit Ref.	Description	Works Ref.
		RESISTORS (continued)	
79	R80	Carbon, High Stability, 91.6 Ω ±1%, 1/8 W.	37-TM4297A
80	R81	Carbon, High Stability, 91.6 Ω ±1%, 1/8 W.	37-TM4297A
81	R82	Carbon, High Stability, 82.5 Ω ±1%, 1/8 W.	36-TM4297A
82	R83	Carbon, High Stability, 17.9 Ω ±1%, 1/8 W.	24-TM4298/2
83	R84	Carbon, High Stability, 17.9 Ω ±1%, 1/8 W.	24-TM4298/2
84	R85	Carbon, High Stability, 17.9 Ω ±1%, 1/8 W.	24-TM4298/2
85	R86	Carbon, High Stability, 17.9 Ω ±1%, 1/8 W.	24-TM4298/2
86	R87	Carbon, High Stability, 17.9 Ω ±1%, 1/8 W.	24-TM4298/2
87	R88	Carbon, High Stability, 17.9 Ω ±1%, 1/8 W.	24-TM4298/2
88	R89	Carbon, High Stability, 17.9 Ω ±1%, 1/8 W.	24-TM4298/2
89	R90	Carbon, High Stability, 17.9 Ω ±1%, 1/8 W.	24-TM4298/2
90	R91	Carbon, High Stability, 17.9 Ω ±1%, 1/8 W.	24-TM4298/2
91	R92	Carbon, High Stability, 17.9 Ω ±1%, 1/8 W.	24-TM4298/2
92	R93	Carbon, High Stability, 61.2 Ω ±1%, 1/8 W.	28-TM4298/2
93	R94	Carbon, High Stability, 332 Ω ±1%, 1/8 W.	26-TM4298/2
94	R95	Carbon, High Stability, 167 Ω ±1%, 1/8 W.	27-TM4298/2
95	R96	Carbon, High Stability, 167 Ω ±1%, 1/8 W.	27-TM4298/2
96	R97	Carbon, High Stability, 167 Ω ±1%, 1/8 W.	27-TM4298/2
97	R98	Carbon, High Stability, 167 Ω ±1%, 1/8 W.	27-TM4298/2

SOS Item No.	Circuit Ref.	Description	Works Ref.
		RESISTORS (continued)	
98	R99	Carbon, High Stability, 37.5 Ω ±1%, 1/8 W.	25-TM4298/2
99	R100	Carbon, High Stability, 90 Ω ±2%, 1/8 W.	12-TM4736/2
100	R101	Carbon, High Stability, 90 Ω ±2%, 1/8 W.	12-TM4736/2
101	R102	Carbon, High Stability, 360 Ω ±1%, 1/8 W.	13-TM4736/2
102	R103	Carbon, High Stability, 37.5 Ω ±5%, 1/8 W.	10-TM4308/2
103	R104	Carbon, High Stability, 75 Ω ±5%, 1/8 W.	11-TM4308/2
104	R105	Carbon, High Stability, 14.5 Ω ±5%, 1/8 W.	12-TM4308/2
105	R106	Composition, 560 Ω ±10%, 1/4 W.	PC66609/16
106	R107	Composition, 22 kΩ ±10%, 1/4 W.	PC66609/35
107	R108	Composition, 1 MΩ ±10%, 1/4 W.	PC66609/55
108	R109	Composition, 2.2 kΩ ±10%, 1/4 W.	PC66609/23
109	R110	Composition, 100 Ω ±10%, 1/4 W.	PC66609/7
110	R111	Composition, 10 kΩ ±10%, 1/4 W.	PC66609/31
111	R112	Wire-Wound, 50 kΩ, Variable, 2 W.	81-TF995A/2
112	R113	Composition, 68 kΩ ±10%, 1 W.	57-TF995A/2
113	R114	Composition, 100 kΩ ±10%, $\frac{1}{2}$ W.	PC66611/49
114	R115	Composition, 1 kΩ ±10%, 1/4 W.	PC66609/33
115	R116	Composition, 330 Ω*, 1/4 W.	PC66609/13
116a	R117	Composition , 2.2 kΩ ±10%, 1/4 W.	PC66609/23

* Nominal value; actual value determined during calibration.

SOS Item No.	Circuit Ref.	Description	Works Ref.
		RESISTORS (continued)	
117	R118	Composition, 22 kΩ ±10%, 1/4 W.	PC66609/35
118a	R119	Composition, 68 kΩ ±10%, 1/4 W.	PC66609/41
119	R120	Composition, 33 kΩ ±10%, 1/4 W.	PC66609/37
119/1	R121	Wire-Wound, 950 Ω ±10%, 1 W.	82-TF995A/2
119/2	R122	Composition, 33 kΩ ±10%, 1/4 W.	PC66609/43
119/3	R123	Composition, 470 Ω ±10%, ½ W.	PC66611/23
119/4	R124	Wire-Wound, 25 Ω Variable, ½ W.	130-TM4826/2
		CAPACITORS	
120	C1	Paper, 0.1 μF ±20%, 350 V d.c.	PC19202/14
121	C2	Paper, 0.1 μF ±20%, 350 V d.c.	PC19202/14
122	C3	Mica, Special Assembly, 100 μμF, Nominal.	2-TM4826/2
123	C4	Mica, 100 μμF ±10%, 350 V d.c.	117-TM4826/2
124	C5	Mica, 100 μμF ±10%, 350 V d.c.	117-TM4826/2
125	C6	Paper, 0.02 μF*, 350 V d.c.	12-TM4800/2
126	C7	Mica, 200 μμF ±20%, 350 V d.c.	71-TM4826/2
127	C8	Mica, 100 μμF ±10%, 350 V d.c.	95-TF 995A/2

* Nominal value; actual value determined during calibration.

SOS Item No.	Circuit Ref.	Description	Works Ref.
		CAPACITORS (continued)	
128	C9	Mica, 100 µµF ±20%, 350 V d.c.	86-TF995A/2
129	C10	Mica, Special Assembly, 100 µµF, Nominal.	2-TM4826/2
130	C12	Mica, Special Assembly, 100 µµF, Nominal.	2-TM4826/2
131	C13	Mica, 100 µµF ±10%, 350 V d.c.	117-TM4826/2
132	C14	Paper, 2 µF ±25%, 250 V d.c.	87-TF995A/2
133	C15	Paper, 0.01 µF ±20%, 350 V d.c.	13-TM4800/2
134	C16	Paper, 0.01 µF ±25%, 350 V d.c.	15-TM4800/2
135	C17	Paper, 0.1 µF ±20%, 350 V d.c.	PC19202/14
136	C18	Paper, 0.1 µF ±20%, 350 V d.c.	PC19202/14
137	C19	Mica, Special Assembly, 100 µµF, Nominal.	3-TM4826/2
138	C20	Ceramic, 0.01 µF -20% +100%.	135-TM4826/2
139	C21	Ceramic, 0.001 µF ±20%, 400 V d.c. Included in Item 206.	12-TM3900/75
140	C22	Mica, Special Assembly, 100 µµF, Nominal. Included in Item 206.	9-TM3900/75
141	C23	Mica, 100 µµF ±10%, 350 V d.c.	86-TM4826/2
142	C24	Paper, 0.001 µF ±20%, 600 V d.c.	91-TM4826/2
143	C25	Mica, 39 µµF ±5%, 350 V d.c.	85-TM4826/2
144	C26	Paper, 0.1 µF ±20%, 350 V d.c.	PC19202/14

SOS Item No.	Circuit Ref.	Description	Works Ref.
		CAPACITORS (continued)	
145	C27	Paper, 0.001 μF ±20%, 600 V d.c.	91-TM4826/2
146	C28	Paper, 0.01 μF ±20%, 350 V d.c.	83-TM4826/2
147	C29	Mica, 47 μμF ±20%, 350 V d.c. Included in Item 207.	9-TM3900/74
148	C30	Ceramic, 4.7 μμF ±20%, 500 V d.c. Temperature Compensation, $(-3000 \pm 10\%) \times 10^{-6}$ μμF/μμF/°C.	89-TM4826/2
149	C31	Ceramic, 100 μμF ±5%, 500 V d.c.	88-TM4826/2
150	C32	Paper, 2 μF ±25%, 150 V d.c.	151-TM4826/2
151	C33	Ceramic, 1 μμF ±20%, 500 V d.c.	82-TM4826/2
152		Two-section ganged capacitor complete with trimmers; includes C34, C35, C46, and C47.	TC1478/1
	C34	Air, Variable, 14 - 200 μμF, part of Item 152.	
	C35	Air, Trimmer, 3 - 30 μμF, part of Item 152.	
153	C36	Ceramic, 47 μμF ±20%, 500 V d.c.	76-TM4826/2
154	C37	Paper, 0.1 μF ±20%, 350 V d.c.	PC19202/14
155	C38	Ceramic, 100 μμF ±20%, 500 V d.c.	84-TM4826/2
156	C39	Paper, 0.01 μF ±20%, 350 V d.c.	83-TM4826/2
157	C40	Air, Trimmer, 1.25 - 10 μμF.	116-TM4826/2
158a	C41	Ceramic, 3.3 μμF ±10%, 750 V d.c.	75-TM4826/2
159	C42	Ceramic, 4700 μμF -0 +100%, 500 V d.c.	92-TM4826/2

SOS Item No.	Circuit Ref.	Description	Works Ref.
		CAPACITORS (continued)	
160	C43	Ceramic, 5 μμF ±20%, 750 V d.c.	134-TM4826/2
161	C44	Ceramic, 10 μμF ±20%, 750 V d.c.	PC18201/9
162	C45	Paper, 0.5 μF ±25%, 150 V d.c.	150-TM4826/2
	C46	Air, Variable, 7 - 100 μμF, part of Item 152.	
	C47	Air, Trimmer, 2 - 8 μμF, part of Item 152.	
163	C48	Ceramic, 100 μμF ±20%, 500 V d.c.	84-TM4826/2
164	C49	Ceramic, 22 μμF ±20%, 500 V d.c.	87-TM4826/2
165	C50	Ceramic, 47 μμF ±20%, 500 V d.c.	73-TM4826/2
166	C51	Mica, 100 μμF ±10%, 350 V d.c.	117-TM4826/2
167	C52	Mica, Special Assembly, 100 μμF, Nominal.	4-TM4826/2
168	C53	Electrolytic, 2 μF -20% +50%, 150 V d.c.	103-TF995A/2
169	C54	Paper, 0.1 μF ±25%, 250 V d.c.	93-TF995A/2
170	C55	Ceramic, 33 μμF ±10%, 500 V d.c.	PC18202/7
171	C56	Mica, 100 μμF ±10%, 350 V d.c.	117-TM4826/2
172	C57	Mica, Special Assembly, 100 μμF, Nominal.	124-127-TM4826/2
173	C58	Electrolytic, 8 μF -20% +50%, 450 V d.c.	33-TM4299/2
174	C59	Air, Trimmer, 1.25 - 10 μμF.	116-TM4826/2
175a	C60	Ceramic, Stand-Off, 820 μμF ±20%, 750 V d.c.	79-TM4826/2
176	C61	Ceramic, 5 μμF ±20%, 500 V d.c.	118-TM4826/2

SOS Item No.	Circuit Ref.	Description	Works Ref.
		CAPACITORS (continued)	
177	C62	Electrolytic, 30 µF -20% ±50%, 350 V d.c.	13-TM4299/2
178	C63	Paper, 0.01 µF ±20%, 350 V d.c.	83-TM4826/2
179	C64	Ceramic, 100 µµF ±20%, 750 V d.c.	PC18202/13
180		Three-section ganged capacitor complete with trimmers; includes C65, C66, C75, C76, C81 and C83.	TC21478/2
	C65	Air, Variable, 7 - 100 µµF; part of Item 180.	
	C66	Air, Trimmer, 2 - 8 µµF; part of Item 180.	
181	C67	Ceramic, 22 µµF ±20%, 500 V d.c.	87-TM4826/2
182	C68	Paper, 0.01 µF ±20%, 350 V d.c.	83-TM4826/2
183	(C69 (and (C71	Electrolytic, Dual Section, 16 µF -20% +50% 8 µF -20% +50%, 350 V d.c.	12-TM4299/2
184	C70	Ceramic, 100 µµF ±20%, 500 V d.c.	84-TM4826/2
	C71	See Item 183.	
185a	C72	Ceramic, Stand-Off, 820 µµF ±20%, 750 V d.c.	79-TM4826/2
186	C73	Ceramic, 5 µµF ±20%, 500 V d.c.	118-TM4826/2
187	C74	Ceramic, 100 µµF ±20%, 750 V d.c.	PC18202/13
	C75	Air, Variable, 7 - 100 µµF, part of Item 180.	
	C76	Air, Trimmer, 2 - 8 µµF, part of Item 180.	
188	C77	Ceramic, 10 µµF ±20%, 500 V d.c.	80-TM4826/2

SOS Item No.	Circuit Ref.	Description	Works Ref.
		CAPACITORS (continued)	
189	C78	Ceramic, 100 µµF ±20%, 500 V d.c.	84-TM4826/2
190	C79	Paper, 6 µF ±20%, 150 V d.c.	79-TF995A/2
191	C80	Ceramic, 100 µµF ±20%, 750 V d.c.	PC18202/13
	C81	Air, Variable, 7 - 75 µµF, part of Item 180.	
192a	C82	Ceramic, Stand-Off, 820 µµF ±20%, 750 V d.c.	79-TM4826/2
	C83	Air, Trimmer, 2 - 8 µµF, part of Item 180	
193	C84	Paper, 100 µµF ±20%, 300 V a.c.	80-TF995A/2
194	C85	Paper, 100 µµF ±20%, 300 V a.c.	80-TF995A/2
195	C86	Paper, 100 µµF ±20%, 300 V a.c.	80-TF995A/2
196	C87	Paper, 100 µµF ±20%, 300 V a.c.	80-TF995A/2
197	C88	Ceramic, 820 µµF ±20%, 350 V d.c.	41-TM4297A
198	C89	Ceramic, 820 µµF ±20%, 350 V d.c.	41-TM4297A
199	C90	Ceramic, 820 µµF ±20%, 350 V d.c.	41-TM4297A
200	C91	Paper, 0.1 µF ±20%, 350 V d.c.	PC19202/14
201	C92	Paper, 0.25 µF ±20%, 500 V d.c.	32-TM4299/2
201/1	C93	Ceramic, 5 µµF ±20%, 500 V d.c.	118-TM4826/2
201/2	C94	Ceramic, 120 µµF ±10%, 750 V d.c.	74-TM4826/2
201/3	C95	Ceramic, 68 µµF ±10%, 750 V d.c.	90-TM4826/2
201/4	C96	Ceramic, 3.3 µµF ±10%, 750 V d.c.	75-TM4826/2

SOS Item No.	Circuit Ref.	Description	Works Ref.
		INDUCTORS	
202	L1	R.F. Filter Inductor.	TM4087/14
203	L2	R.F. Filter Inductor.	TM4087/14
204	L3	R.F. Inductor.	TB16363/27
205	L4	R.F. Filter Inductor	TM4087/14
206		Main portion of three-section filter assembly; includes L6 and L7, and Items 138 and 139.	TM3900/75
	L6	R.F. Filter Inductor; part of Item 206.	
	L7	R.F. Filter Inductor; part of Item 206.	
207	L8	Screened R.F. Inductor Assembly; includes Item 146.	TM3900/74
208	L9	Modulation Choke.	TM4159/1
209	L10	30-Mc/s Oscillator Inductor.	TB23173/1
210	L11	Screened R.F. Inductor Assembly.	TM4087/14
211	L14	R.F. Inductor.	TB23173/3
212	L15	R.F. Inductor.	TB23173/4
213	L16	Shrouded H.T. Smoothing Choke (earlier models)	TM4140/1A
213/1	L16	Unshrouded H.T. Smoothing Choke (later models)	TM5172/31
214	L17	Shrouded H.T. Smoothing Choke (earlier models)	TM4140/1A
214/1	L17	Unshrouded H.T. Smoothing Choke (later models)	TM5172/31
215	L18	Multiplier Tuning Inductor, 27 to 55 Mc/s.	TA22011

SOS Item No.	Circuit Ref.	Description	Works Ref.
		INDUCTORS (continued)	
	L19	R.F. Inductor; part of Item 61.	TB23173/10
	L21	R.F. Inductor; part of Item 55.	TB23173/9
217	L22	Multiplier Tuning Inductor, 54 to 110 Mc/s.	TB20309/1
218	L23	Multiplier Tuning Inductor, 108 to 220 Mc/s.	TE23048/11
219	L24	R.F. Inductor (mains filter).	TA14323/18
220	L25	R.F. Inductor (mains filter).	TA14323/18
220/1	L26	Filter Inductor	TB23173/39
		TRANSFORMERS	
221	T1	A.F. Oscillator Transformer.	TM4085/2
222	T2	Master Oscillator R.F. Transformer, 4.5 to 9 Mc/s.	TM3900/87
223	T3	Multiplier R.F. Transformer, 13.5 to 27 Mc/s.	TM3900/52
224	T4	Mains Transformer with separate mains-tapping panel (earlier models).	TM4501
224/1	T4	Mains Transformer with all connections directly to tags on transformer coil (later models)	TM5150/25
225	T5	R.F. Output Transformer, 2 to 13.5 Mc/s.	TB23173/5

SOS Item No.	Circuit Ref.	Description	Works Ref.
		SWITCHES	
226	S1	Rotary, 8 pole, 5 position, 4 wafer.	TC4428/373
227	S2	Rotary, 10 pole, 5 position, 4 wafer.	TC4428/366
228	S3	Lever-Actuated Rotary, 2 pole, 3 position, 2 wafer, biased to mid-position; includes bakelite handle.	TC4428/342
229a	S4	Toggle, 2 pole, 2 position.	TB23903/2
230	S5	Rotary, 2 pole, 2 position, single wafer.	96-TM4826/2
231	S6	Rotary, 4 pole, 2 position, single active wafer, with extra dummy wafer.	TC4428/344
231/1	S7	Toggle, 2 pole, 2 position.	TB23903/2
		VALVES, VALVE HOLDERS, AND RETAINERS	
232	V1	6AK6, Pentode.	47-TF995A/2
233		Holder, for V1.	TB26904/2
234		Retainer, for V1.	PC17501/2
235	V2	6AK6, Pentode.	100-TM4826/2
236		Holder, for V2.	TB26904/2
237		Retainer, for V2.	PC17501/2
238	V3	6AK5, Pentode.	101-TM4826/2

SOS Item No.	Circuit Ref.	Description	Works Ref.
		VALVES, VALVE HOLDERS, AND RETAINERS (continued)	
239		Holder, for V3.	TB26904/2
240		Retainer, for V3.	PC17501/1
241	V4	6AK5, Pentode.	101-TM4826/2
242		Holder,for V4.	TB26904
243		Retainer, for V4.	PC17501/1
244	V5	6AU6, Pentode.	49-TF995A/2
245		Holder, for V5.	TB26904/2
246		Retainer, for V5.	PC17501/2
247	V6	6AK5, Pentode.	101-TM4826/2
248		Holder, for V6.	TB26904
249		Retainer, for V6.	PC17501/1
250	V7	12AT7, Double Triode.	103-TM4826/2
251		Holder, for V7.	TB26905/2
252		Retainer, for V7.	PC17502/2
253	V8	6AK5, Pentode.	101-TM4826/2
254		Holder, for V8.	TB26904
255		Retainer, for V8.	PC17501/1
256	V9	OA2, Voltage Stabilizer.	48-TF995A/2
257		Holder, for V9.	TB26904/2
258		Retainer, for V9.	PC17501/2

SOS Item No.	Circuit Ref.	Description	Works Ref.
		VALVES, VALVE HOLDERS, and RETAINERS (continued)	
259	V10	6AK5, Pentode.	101-TM4826/2
260		Holder, for V10.	TB26904
261		Retainer, for V10.	PC17501/1
262	V11	5Z4G, F.W. Rectifier.	16-TM4299/2
263		Holder, for V11.	PC81814/1
264		Retainer, for V11.	TC22744/12
265	V12	6AK5, Pentode.	101-TM4826/2
266		Holder, for V12.	TB26904
267		Retainer, for V12.	PC17501/1
268	V13	6AL5, Double Diode.	46-TF995A/2
269		Holder, for V13.	TB26904/2
270		Retainer, for V13.	PC17501/2
271a	V14	5651, Voltage Stabilizer.	20-TM4299/2
272		Holder, for V14.	TB26904/2
273		Retainer, for V14.	PC17501/2
274	V15	6AL5, Double Diode.	21-TM4299/2
275		Holder, for V15.	TB26904/2
276		Retainer, for V15.	PC17501/1

SOS Item No.	Circuit Ref.	Description	Works Ref.
		CRYSTALS	
277	X1	Quartz Oscillator Crystal, 333.33 kc/s.	102-TM4826/2
278		Holder, for X1.	98-TM4826/2
279		Retainer, for X1.	99-TM4826/2
280	X2	CS2A, Silicon Rectifier.	40-TM4297/2
281		Retaining Contact, for X2.	TD20400/7
		LAMP	
282	PL1	Pilot Lamp, 6.5 V, 0.3 A, M.E.S.	32-TF995A/2
283		Pilot Lamp Holder, with Red Lens.	42-TF995A/2
		METER	
284	M1	0-100 μA, 500 Ω Nominal, Moving Coil, including clamping brackets.	TM3970/30
		PLUGS, SOCKETS, and CONNECTING LEADS	
285	P1	Plug, 6-way.	18-TM4299/2
286	SK1	Socket, 6-way.	55-TF995A/2

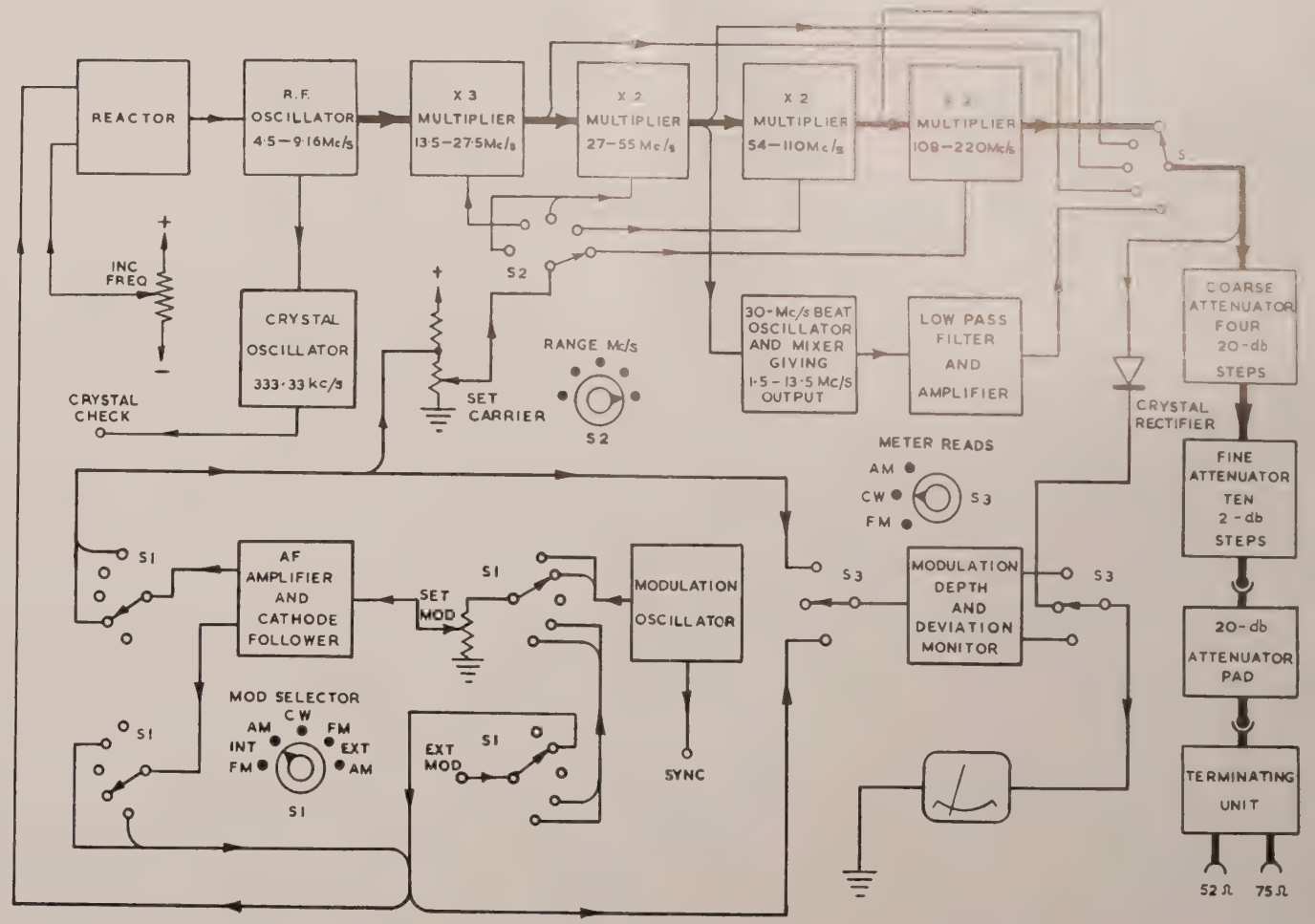
SOS Item No.	Circuit Ref.	Description	Works Ref.
		PLUGS, SOCKETS, and CONNECTING LEADS (continued)	
287		Mains Lead comprising 6-ft, 3-core Flexible Cable and 3-pin plug complete with Plastic Entry Sleeve.	TM2560AQ
288		R.F. Output Plug, coaxial, free.	30-TM4298/2
289		R.F. Output Cable, coaxial, 4 ft 6 in.	38-TM4298/2
290	J1	CRYSTAL CHECK Jack Socket, including Jack Plug.	54-TF995A/2
291		Bush, for Item 290.	TA19742
292		R.F. Socket, coaxial, fixed.	7-TM4308/2
		KNOBS, DRIVES, and DIALS	
293a		Knobs, for TUNE and INC FREQ controls.	TB29569
294		TUNE control dial.	TC20320/4
295		INC FREQ control dial.	TB23220
296		Set of three Special Screws for fixing dials to knobs.	TA4014
297		Cursors, for TUNE and INC FREQ Dials.	TA20308
298a		FREQUENCY DIAL. Pre-calibrated.	TB23189
299		Dial Escutcheon Mounting Ring.	TD20670/2
300		Dial Escutcheon (Chromium Plated), with Rubber Tubing Gasket, to fit over Item 299.	TD20670/1 8-TM4357/2

SOS Item No.	Circuit Ref.	Description	Works Ref.
		KNOBS, DRIVES, and DIALS (continued)	
301		Window, including Movable Cursor Assembly, to fit in Item 300.	TC20735/2 TD20670/3 TA20726 TB6775/300 6-TM4357
302		Nylon Drive Cord.	12-TM4826/2
303		Knob, for MOD SELECTOR switch, S1.	TB25460/2
304		Knob, for RANGE MC/S switch, S2.	TB25460/2
305		Knob, for DEVIATION-NORMAL/HIGH switch, S5.	TB25460/2
306		Knob, for DEVIATION RANGE switch, S6.	TB25460/2
307		Knob, for OUTPUT VOLTAGE attenuator.	TB17848/3
308		Knob, for MULTIPLY BY attenuator.	TB17848/3
309		Knob, for SET CARRIER control, R44.	TB23920/1
310		Knob, for SET MOD control, R25.	TB23920/1
		MISCELLANEOUS	
311		Cover Plate, for R.F. Output Cable exit, in Right-Hand Handle Recess.	TA19721
312		Grommet, to fit in Item 311.	TA6515/1

SOS Item No.	Circuit Ref.	Description	Works Ref.
		MISCELLANEOUS (continued)	
313		Cable Saddle, to secure Item 289 to Item 311.	29-TF995A/2
314a		Front Panel.	TD22009/2
315		Set of Eight Screws, complete with Black Fibre Washers for fixing Front Panel to case.	30-TF995A/2 TB6775/183
316		Terminal, EXT MOD.	TB24330/5
317		Terminal, SYNC.	TB24330/5
318		Terminal, EARTH.	TB24330/5
319		Case Assembly complete with Handles and Feet.	TM4310 TB18258 TA11420
320		Handle Escutcheon. Two included in Item 319.	TB18258
321		Case Foot. Four included in Item 319.	TA11420
322			
323		20-dB Step Attenuator Assembly; includes Items 70 to 81 inclusive, 197, 198, 280 and 281.	TM4297
324		2-dB Step Attenuator Assembly; includes Items 82 to 98 inclusive.	TM4298
325		20-dB ATTENUATOR PAD; includes Item 99 to 101 inclusive, and Item 292.	TM4736
326		52- and 75-ohm TERMINATING UNIT; includes Items 102 to 104 inclusive, and Item 292.	TM4308

SOS Item No.	Circuit Ref.	Description	Works Ref.
		MISCELLANEOUS (continued)	
327		R.F. Unit Screening Cover.	TD20318 26A-TM4826
328		Contact Spring for earthing R.F. Unit Screening Cover.	TC-20321/3E
329		Set of three Hexagonal Wrenches for Socket Set Screws, sizes 2, 4, and 6BA; complete in linen bag.	104-TF995A/2
330		Operating and Maintenance Handbook.	OM995A/2

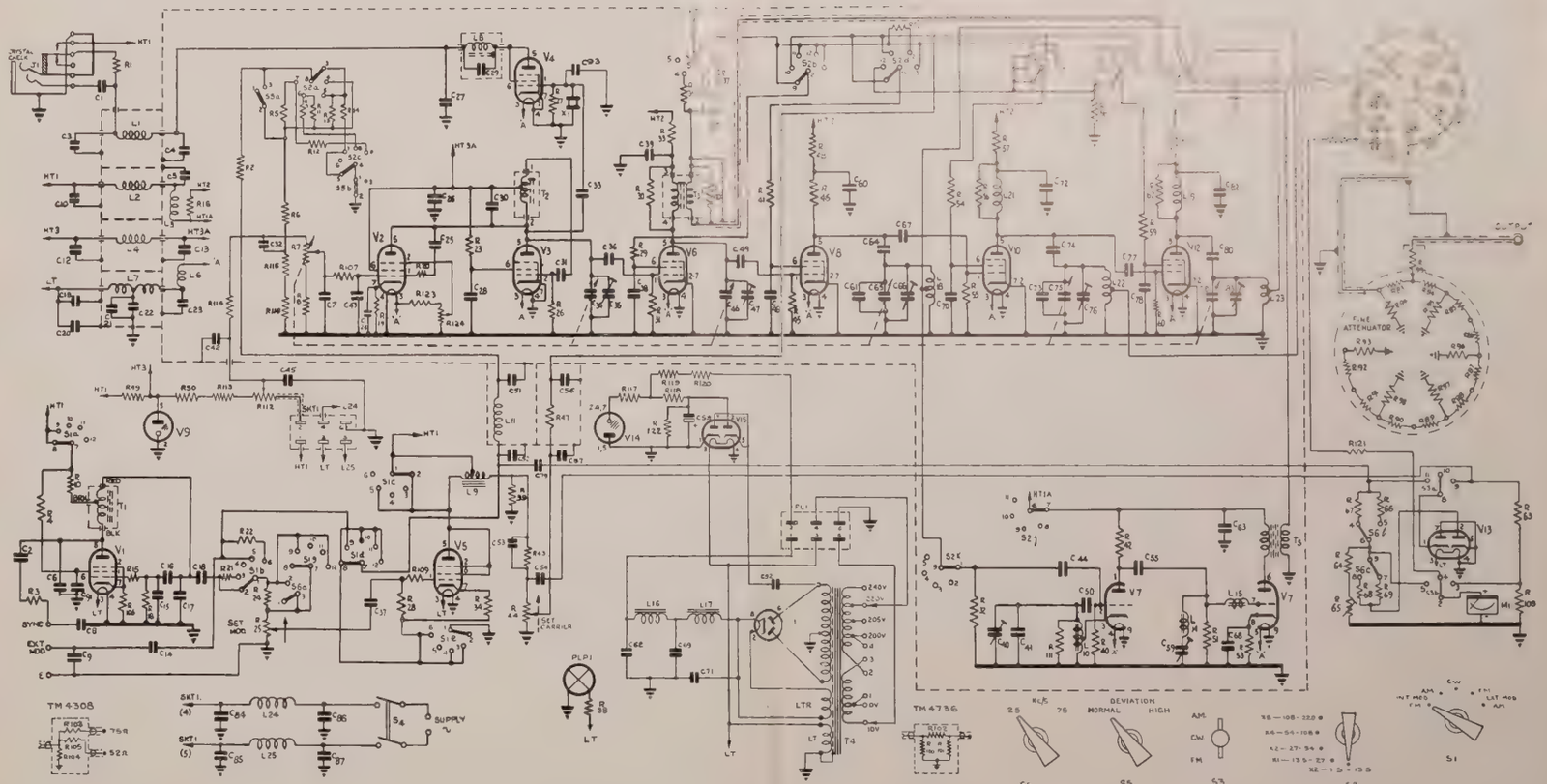
BLOCK SCHEMATIC DIAGRAM



BLOCK SCHEMATIC DIAGRAM

MARCONI INSTRUMENTS LIMITED							
DRN	A.B.R.	DATE	3/59	CHKD	A.B.R.	ISSUE	1
STOCK LIST	TF 995A/2		DRG No.	TLC 23556/2			

CIRCUIT DIAGRAM



CIRCUIT DIAGRAM

MARCONI INSTRUMENTS LIMITED							
DRN	D.R.H.	DATE	3/57	CHKD	B.R.C.	ISSUE	6
STOCK LIST	TF 995A/2		DRG No.	TLD 23080/2			

TLD 23080/2

DECIBEL CONVERSION TABLE

Ratio Down			*Ratio Up*	
VOLTAGE	*POWER*	*DECIBELS*	*VOLTAGE*	*POWER*
1·0	1·0	**0**	1·0	1·0
·9886	·9772	**·1**	1·012	1·023
·9772	·9550	**·2**	1·023	1·047
·9661	·9333	**·3**	1·035	1·072
·9550	·9120	**·4**	1·047	1·096
·9441	·8913	**·5**	1·059	1·122
·9333	·8710	**·6**	1·072	1·148
·9226	·8511	**·7**	1·084	1·175
·9120	·8318	**·8**	1·096	1·202
·9016	·8128	**·9**	1·109	1·230
·8913	·7943	**1·0**	1·112	1·259
·8710	·7586	**1·2**	1·148	1·318
·8511	·7244	**1·4**	1·175	1·380
·8318	·6918	**1·6**	1·202	1·445
·8128	·6607	**1·8**	1·230	1·514
·7943	·6310	**2·0**	1·259	1·585
·7762	·6026	**2·2**	1·288	1·660
·7586	·5754	**2·4**	1·318	1·738
·7413	·5495	**2·6**	1·349	1·820
·7244	·5248	**2·8**	1·380	1·905
·7079	·5012	**3·0**	1·413	1·995
·6683	·4467	**3·5**	1·496	2·239
·6310	·3981	**4·0**	1·585	2·512
·5957	·3548	**4·5**	1·679	2·818
·5623	·3162	**5·0**	1·778	3·162
·5309	·2818	**5·5**	1·884	3·548
·5012	·2512	**6**	1·995	3·981
·4467	·1995	**7**	2·239	5·012
·3981	·1585	**8**	2·512	6·310
·3548	·1259	**9**	2·818	7·943
·3162	·1000	**10**	3·162	10·000
·2818	·07943	**11**	3·548	12·59
·2512	·06310	**12**	3·981	15·85
·2239	·05012	**13**	4·467	19·95
·1995	·03981	**14**	5·012	25·12
·1778	·03162	**15**	5·623	31·62

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